3-2008

Inland Resupply without a Road or Runway: Airdrop Solutions Including High-Altitude Precision Systems

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THESIS

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AFIT/GLM/ENS/08-15

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THESIS

Presented to the Faculty

Department of Operational Sciences

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

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March 2008

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

AFIT/GLM/ENS/08-15

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AFIT/GLM/ENS/08-15

Abstract

Given the variety of airdrop options now available, it may be difficult to determine the best mix of paradrop and aircraft types to employ, how the chosen types affect delivery weight capacity and what the least cost would be for the operation while still accomplishing the mission regarding drop zone weight, altitude, offset, and accuracy requirements. This research creates a planning tool to analyze these decisions and also identify trends regarding the best aircraft and paradrop types to use considering cost and capability in a strategic rather than tactical setting. This is accomplished through the formulation of a linear program implemented as a spreadsheet model for several different scenarios. This research indicates that new high-altitude precision airdrop (HAPAD) systems will make conventional airdrop obsolete due to both cost and performance and that C-5 aircraft, if used, have the potential to dramatically increase airdrop capacity at competitive cost, particularly when using 30,000 lb HAPAD. Also, regarding cost, this research suggests airdrop system design life needs to match life expectancy and that all relevant costs must be included to make an accurate comparison with alternative resupply methods.

Acknowledgments

First and foremost, I would like to thank my family and friends for their support and understanding during my entire AFIT program.

Next, I would like to express my sincere appreciation to my faculty advisor, Maj Shane Hall whose patience, encouragement and insight were crucial to this project.

Additionally, I would like to recognize the professionals who generously contributed vital information to my research, specifically: Mr. Richard Benney and Mr. Scott Martin from the USA Natick Soldier Center, Mr. Storm Dunker with Airborne Systems, Dr. Phil Hattis with Draper Laboratories, MSgts Thomas Fields, Andrew Hoots, and James McElwee in the AMC Airlift Branch, and SSgt Brian Leverton, a convoy veteran with whom I had the privilege of serving with at Whiteman AFB, MO.

Derek L. Williamson

Table of Contents

List of Figures

Page

List of Tables

Page

INLAND RESUPPLY WITHOUT A ROAD OR RUNWAY:

AIRDROP SOLUTIONS INCLUDING HIGH ALTITUDE PRECISION SYSTEMS

I. Introduction

Overview

This chapter discusses why the U.S. Air Force is considering inland resupply without a road or runway and how high-altitude precision systems have allowed for a new means to accomplish this goal. Next it identifies a problem in establishing airdrop capacity and cost, and how this research will addresses this problem. Finally, the chapter concludes with a brief outline of the thesis.

Background

As long as people have been dropping things out of aircraft they have been trying to figure out how to do it more accurately. In the early days of aviation this amounted to little more than mechanical heuristics considering elevation and speed and, maybe, trying to account for wind (Mink 1944). The real revolution came with the advent and integration of the global positioning system (GPS). For the first time a payload could actually recognize where it was, where the target was, and could autonomously guide itself to the target without any input from an aircraft or ground unit after its deployment (Varner 2000). This was applied to cargo delivery in the form of the U.S. Army's Guided Parafoil Airdrop Delivery System (GPADS) in which a GPS guidance unit on top of a cargo package was connected to a parafoil through mechanical actuators. With this came a capability for Standoff Precision Airdrop (SOPAD) wherein cargo is intentionally dropped at an offset from the intended impact point within a range that the guidance unit can correct for as detailed in Varner (2000). Later, with U.S. Air Force collaboration for mission planning, GPADS evolved into the Joint Precision Airdrop System (JPADS) as discussed in King (2006).

The origins of airdrop did not include airlift and, even with the advent of aircraft, it was only a secondary mission for bombers (Mink 1944). However, today it is a well defined, though still evolving, facet of our military capability.

Airlift can be classified as strategic or tactical. Typically, tactical airlift is within a theatre of operations (intratheatre) over relatively short distances using relatively small aircraft including helicopters, such as the Boeing CH-47 Chinook, or airplanes, such as the Lockheed Martin C-130 Hercules. Strategic airlift is generally over a relatively long distance, typically spanning continents (intertheatre), using relatively large aircraft such as the Boeing C-17 Globemaster III and the Lockheed Martin C-5 Galaxy (Airlift 1999). Airlift is also commonly divided into airland and airdrop activities. Airland are those operations for which the aircraft lands at the destination whereas in airdrop it does not.

Airdrop is further divided by type into low-velocity, high-velocity and free-fall operations. In low-velocity drops, decelerators (chutes and foils) slow the load as much as possible to minimize impact force. This type of drop is commonly used for delicate equipment and vehicles. With high-velocity drops a relatively small chute stabilizes the load but the impact force is much greater. This type of drop may be used for more durable items such as Meals Ready-to-Eat (MREs). With free fall drops no chute is used. This type of drop is commonly used for leaflets (Aerial 2003).

Airdrop may also be categorized by the method it leaves the aircraft. Extraction drops use a chute to pull the load out of the aircraft. Gravity drops use the attitude of the aircraft to roll loads out. Door bundle drops are pushed out by the aircrew (Aerial 2003).

With the advent of high-altitude precision airdrop (HAPAD) new distinctions are made. As the name indicates, high-altitude precision airdrop systems are designed for altitudes up to 24,500 feet, whereas conventional airdrop is generally accomplished from around 1,000 feet (Benney 2005). Also, HAPAD may be either ballistic or guided. With a high-altitude precision ballistic airdrop, the JPADS Mission Planner (JPADS-MP) is used to calculate the best release point but no guidance system is employed. A high-altitude precision guided airdrop incorporates the whole JPADS ensemble including both mission planning and guidance equipment, which is detailed in the JPADS supplement, Appendix C.

In summary, high-altitude precision airdrop may be a low-velocity or high-velocity ballistic or guided drop type that may use either a gravity or chute extraction method. It is used primarily for intratheatre tactical airlift but as an intertheatre direct delivery method, airdrop has the potential to replace insecure land based transshipment.

Problem Statement

Currently, HAPAD is used primarily for tactical resupply, providing food, water, ammunition and medical supplies to small units. This mission, while vital and with proven impact, only begins to exploit its possibilities. There are many situations in which a larger force may need sustainment for which airdrop is the only option. Any number of historical examples would include situations in which a force landed in a coastal region and moved inland but was cut off from the shore, the force paradropped into the combat zone, or perhaps the force arrived by airland or surface transportation through a host nation that subsequently withdrew its support. Furthermore, the number of operable U.S. bases continues to decrease while the number of threat locations continues to increase. Therefore, the ability to support forces by airland operations is compromised and strategic airdrop should be considered as a means to maintain an adequate level of support. Because of drop zone altitude, offset and size limitations, airdrop sustainment must include HAPAD. Headquarter Air Force (HQAF) Strategic Planning office, A8X, has expressed interest in this strategic application of high-altitude precision airdrop (Garretson 2007). HAPAD systems can now quickly and safely support operations that were previously inaccessible by any method. However, given the variety of airdrop options now available, it is unknown what is the best mix of airdrop options to employ, how the chosen airdrop type affects delivery weight capacity and what the least cost would be for the operation while still accomplishing the mission regarding drop zone weight, altitude, offset, and accuracy requirements.

Research Focus

Research Objective

This research describes a model and methodology to determine the least costly mix of aircraft and airdrop types to employ in a given scenario to meet a sustainment requirement using only airdrop (including HAPAD) in a strategic setting.

Research Tasks

The research objective is met through several subordinate tasks: (1) data collection to identify the performance characteristics of each aircraft type and drop type that will be used; (2) scenario development to describe the distance between origins and destinations as well as the supply capability at each origin and demand requirements at each destination; (3) model formulation and implementation to process the data collected; and finally, (4) comparison between the airdrop solution and conventional methods.

Research Scope

This research will incorporate the Lockheed Martin C-130 Hercules including the new longer C-130-J30, the Boeing C-17 Globemaster III, and the Lockheed Martin C-5 Galaxy which comprise the bulk of the U.S. Air Force mobility fleet.

The airdrop systems included are classified by their weight in thousands of pounds (annotated by "K"). Conventional airdrop (CAD) is typically accomplished in 2K or 10K sizes but larger packages are possible. However, with larger sizes of conventional airdrop, cost per pound increases, accuracy decreases, and it becomes more challenging to support with common material handling equipment (MHE); therefore, conventional airdrop packages larger than 10K are not considered in this research (Kirsteatter 2006). Although conventional 2K airdrop systems cost per pound and accuracy are slightly better than conventional 10K systems, the difference was not considered significant, and so this research uses only the 10K conventional size for comparison (AFI 13-217 2007). High-altitude precision ballistic systems are available in 2K and 10K sizes, both of which are considered. High-altitude precision-guided systems are available in several sub-2K sizes as well as 2K, 10K, 30K and even 60K systems. The sub-2K sizes have specific applications not geared toward sustainment of a large force (discussed in Appendix C) and, although the 60K system has been conceptualized, it is not currently being planned or programmed; consequently, neither the sub-2K nor the 60K classes are included in this research (Kissel 2007). Therefore, the research examines

10K (low altitude) conventional airdrop; 2K and 10K high-altitude precision ballistic airdrop; and 2K, 10K, and 30K high-altitude precision guided airdrop.

Research Assumptions and Limitations

Because high-altitude precision airdrop systems are fairly novel, several modeling assumptions are made for this research. Because the inventory of HAPAD systems has not yet been established, like Dilanian et al. (2006), this research assumes these systems will be available in the quantity required for each scenario. This research also assumes cargo that can be airdropped can withstand HAPAD or will be modified such that it can; however, the drop loss calculation discussed in Chapter III allows for a percentage of failure. Furthermore, like Dilanian et al. (2006), Kirsteater et al. (2006), and Varner (2000), it is assumed the high-altitude precision airdrop systems will meet design performance goals, particularly concerning accuracy, offset, deployment altitude and number of uses as detailed in Chapter III. Although, according to AMC/A3VX, C-5 aircraft are not currently used for airdrop, they have been in the past and this research assumes they are still capable (Fields 2007).

Research Implications

The JPADS-MP was first used with the Improved Container Delivery System (I-CDS), a 2K sized bundle, for a high-altitude precision ballistic drop in Afghanistan on 29 July 2006 (Whitaker 2006). The first complete JPADS high-altitude precision-guided drop in a combat zone was also in Afghanistan on 31 August 2006 (Kissell 2007). Between July 2006 and September 2007, 4,234 high-altitude precision ballistic I-CDS drops and 222 JPADS high-altitude precision-guided drops were accomplished (Coy 2007). So far most drops have been within 280 yards of the target (VandenBrook 2007), which is significantly less area to secure than would have been required with conventional airdrop, and the JPADS program continues to improve and evolve. Not only have these drops kept aircrews out of harm's way and reliably resupplied ground forces while minimizing the drop zone that they must secure, these drops have also reduced convoy operations. In 2006 mobility aircraft (including the C-130, C-17, C-5, KC-135, and KC-10) were shot at with small arms, rocket-propelled grenades (RPGs) and man portable air defense systems (MANPADS) 215 times and hit 6 times (Coy 2007). Improvised explosive devices (IEDs), which are commonly used in convoy attacks, are the leading combat cause of death in the global war on terrorism (GWOT) accounting for 19,301 injuries and 1,955 deaths as of September 2007 (Coy 2007). Although it may not yet be practical to completely eliminate large convoys, there is hope that the number can be reduced and there may no longer be a need for four or five armed vehicles supporting a small convoy of just two or three trucks (VandenBrook 2007). HAPAD systems have already demonstrated their effectiveness in combat with accuracy and altitude capabilities that were never before possible. If these capabilities were translated to strategic sustainment of larger forces as this research suggests, many more airland and surface operations could be eliminated along with the consequent damage, injury and death.

Thesis Outline

This thesis is organized as follows. Chapter II identifies the literature relevant to an understanding of this research. Chapter III describes the research methodology discussing the formulation and implementation of the linear programming model and defining the scenarios. Chapter IV presents the model's solutions to each scenario as well as an analysis of those results. Chapter V concludes the thesis with recommendations and suggestions for further research. The appendices include information that may be useful to the reader but is not necessary to understand the research.

II. Literature Review

Overview

To build a foundation for this research, this chapter includes a discussion of the origin, capabilities and problems with airlift before high-altitude precision airdrop; a brief description of JPADS and some research that explored its capability and limits; and, finally, some of the research that helped select the methodology for this thesis including a discussion of the minimum cost network flow linear programming model, which is the technique used to apply the research focus discussed in Chapter I to the scenarios described in Chapter III.

Historical Perspectives

The emergence of airdrop

Airdrop was first used for personnel. The Chinese employed an umbrella-like device as a parachute as early as the 12th century. During the 1400s in Europe, the practical use for the parachute was envisioned as a means for escaping burning buildings. In 1914, World War I refocused parachutes as life saving devices for aircraft (Mink 1944). By World War II airlift began to be used in large scale for cargo. From 1935 to 1936 the Italians delivered 2,000 tons of supplies by airlift (both airland and airdrop) to troops in Ethiopia (Wragg 1986). By 1940, one million Russian troops were trained to jump out of functional aircraft, not only for combat, but also to supply remote communities with food, mail and medicine as well as to fight forest fires (Mink 1944). However, the aircraft used for airlift in World War II were bomber-transports rather than true cargo planes as planners were reluctant to dedicate resources strictly to logistics (Wragg 1986).

The Berlin Airlift

Immediately following World War II, Germany was divided into four zones controlled by the Americans, British, French and Russians. Although the city of Berlin was completely inside the Russian zone, it was also divided into four sectors. On June 22, 1948, the Russians completely blocked all surface transportation to western controlled sectors of Berlin (Miller 1998). The United States chose to respond with airlift. At the outset of the operation the U.S. had 98 Douglas C-47 Skytrain aircraft in Europe with a cargo capacity of three tons each. Within two weeks, 300 Douglas C-54 Skymaster aircraft with a cargo capacity of 10 tons each joined the operation (U.S. 2007). Although ground traffic was delivering 13,500 tons of cargo per day before the blockade, estimates were that the airlift would need to last three weeks and provide at least 2,000 tons of cargo per day for basic subsistence (Miller 1998). During the course of the airlift, which lasted 321 days, over 2.3 million tons of cargo was delivered, almost 1.8 million tons by the Americans alone, and the most delivered in 24 hours was 12,940 tons (Miller 1998).

Concerning this research, the two most important impacts of the Berlin airlift as Miller (1998) identified are that it displayed the capability of airlift in a demonstration that has not been surpassed since, and it validated the need for larger military-specific global transports rather than the civilian adaptations that were being used.

Lessons Learned

Several researchers have explored a variety of conflicts from World War II to the present GWOT in both Afghanistan and Iraq in an effort to determine key factors in the success or failure of airdrop operations. This section identifies common themes from some of those researchers. Specifically, Carrabba (2004), Ireland (2006), King (2006), and Vaughan and Donoho (2000) considered conflicts in Afghanistan, the Balkan Peninsula, Iraq, Kosovo, Panama, Russia and Vietnam. From both success and failure, the common themes that emerged are the importance of (1) an accurate cargo requirement estimate and adequate airlift to deliver it, (2) timely and accurate delivery of cargo and (3) a safe delivery method.

Cargo requirements are generally stated in tons per day or tons per day per supported troop. Ideally, a commander would know how much cargo an operation will involve and if that amount can be feasibly supplied to that location before engaging. Although this is often not the case with tactical airdrop, strategic airdrop should allow for these considerations. Naturally, available airlift cannot be guaranteed without an accurate cargo estimate. Furthermore, as Vaughan and Donoho (2000) note, airlift must be available in sufficient quantity as not to impact other operations.

Timely delivery is coupled with accuracy for two reasons. If the accuracy of a drop is so poor as to be unrecoverable it is in effect late. Even if it is recoverable but off target, although the load may have left the aircraft, it has not reached the recipient until they go retrieve it. With conventional airdrop, the higher the deployment altitude the poorer the accuracy and the greater the separation between bundles. This is particularly problematic for large scale sustainment because, even if an entire aircraft load is dropped from under 1,000 feet and the first bundle is on target, the rest of the bundles may be spread roughly in a line over a mile or more (VandenBrook 2007). Timeliness must also factor in resupply distance because the resupply can, at best, be only as responsive as the travel time.

A safe delivery method is one that is safe for both the aircrew and the supported ground unit. For this reason accuracy should be readdressed as the more time a ground unit spends recovering off-target drops the more time they are exposed to hostile fire. Indeed, as Ireland (2006) concludes, the airdrop will fail if the enemy can target the drop zone at will. Air superiority is not typically a problem for modern conflicts; man portable air defense systems (MANPADS) and anti-aircraft artillery (AAA) pose the most significant threat (King 2006). Mitigating such a threat was the impetus for the development of high-altitude airdrop originally using a container delivery system (CDS) package and an airdrop ground radar system (GRADS) in the early 1970's rather than the GPS system used with JPADS (Carrabba 2004).

While still dependent on accurate cargo estimates and adequate airlift, an HAPAD system greatly affects the accuracy and safety of airdrop making it a much more appealing solution.

The Current Joint Precision Airdrop System

In 1997 the U.S. Air Force began collaborating with the U.S. Army's GPADS program by providing the mission planner. The program became JPADS and the mission planner was designated the JPADS-MP. JPADS is an HAPAD system that allows for deployment altitudes up to 24,500 feet with accuracy as small as 50 meters for both the first and last bundle to leave the aircraft (Benny 2005). Today any airdrop that uses the JPADS-MP may be referred to as a JPADS drop but a distinction should be made between precision ballistic drops and precision guided drops.

Precision Ballistic Airdrop

A precision ballistic airdrop (PBA) employs the JPADS-MP run on a specialized laptop computer onboard the aircraft to determine the ideal computed aerial release point (CARP) to deploy the bundle from altitudes up to 24,500 feet (JPADS 2007). When applied to 2K CDS bundles it becomes I-CDS (Diaz 2007). It may also be applied to 10K bundles using a new Enhanced CDS (E-CDS) pallet (Benney 2005).

Precision Guided Airdrop

A precision guided airdrop (PGA) also uses the JPADS-MP allowing for deployment altitudes up to 24,500 feet but additionally employs an Airborne Guidance Unit (AGU) as part of the airdrop bundle (McGowan 2006). The JPADS-MP communicates wirelessly with the AGU identifying the intended Impact Points (IPs) (Cupp 2005). After deployment, the AGU uses a GPS receiver to determine its current position then manipulate the parafoil's risers to adjust its flight toward the IP (Kurle 2006). Because the AGU is able to adjust the flight of the bundle, the CARP can be translated into a Launch Acceptance Region (LAR) from which all bundles can be deployed and still hit the same IP rather than being spread out in a line (Cupp 2005). Not only can all bundles be grouped closer than ever before possible, the AGU also allows for SOPAD in which the aircraft may deploy bundles from up to 20 miles away from the IP (Benney 2005).

Guided JPADS was originally conceived in four increments or sizes: extra-light (2K), light (10K), medium (30K) and heavy (60K). More recently an ultra-light increment for cargo under 1,000 pounds is being developed to support the U.S. Marines (Coy 2007). Also, at least one company has envisioned and demonstrated what may be called a nano-light category for cargo under 400 pounds used to drop things like sensors and communications relays (STARA 2007). Finally, JPADS is also being applied to personnel to enable limited visibility paratroop drops (Benney 2005).

Related Research

Since the development of JPADS several researchers have presented work that was vital in shaping this thesis. These researchers helped identify the appropriate methodology to use for this research, some important factors to include and exclude or challenge, and the overall goal for the research.

Choosing the Method

Ultimately, linear programming using spreadsheet modeling emerged the clear choice for several reasons. As Banks et al. (2005) suggest, computer simulation should only be used when another, generally simpler method such as linear programming, cannot provide the required information. Granger, Krishnamurthy and Robinson (2001) identified that network approximation methods modeled airlift operations sufficiently while requiring a small fraction of the time and computational work that were required for simulation. After all, neither method is perfect, but as Box and Draper (1987) stated "all models are wrong but some are useful". Also, as Stucker and Williams (1999) pointed out, computer simulation generally is designed to find a possible solution, not necessarily the optimum one. This thesis is expressly aimed at finding the least costly airdrop solution, not just a feasible one. This type of problem is well suited to the minimum cost network flow model as discussed shortly hereafter.

Choosing the Focus and Scope

Although the increased safety of airdrop operations is an important benefit of HAPAD systems this research does not focus on it. A good amount of research exists to support the fact that HAPAD is significantly safer than conventional low-altitude airdrop. Using the Air Force THUNDER simulation model, Varner (2000) found that the stand-off capability of HAPAD resulted in less aircraft damage and more supplies reaching the ground unit. Ireland (2006) also stated that airdrop provides freedom of maneuver while mitigating terrain and surface threats. Many other researchers echo these sentiments without challenge but most also state the increased safety comes at a premium cost. For this reason, this research accepts that HAPAD is safer than conventional (low-altitude) airdrop and instead focuses on cost.

Describing the cost of airdrop operations does not have the same consensus as safety. Although many agree that airdrop operations are more expensive than surface methods, the estimates vary greatly. Kirsteatter et al. (2006) made one of the most complete studies and compared the operational effectiveness and cost efficiency of precision airdrop, conventional airdrop, airland, and convoy operations in a scenario including 45,000 troops, C-130 and C-17 aircraft, and 30K and 60K size JPADS. They concluded that convoy operations are the least expensive while precision airdrop is the most expensive and identified that the cost of airdrop is heavily influenced by flying hour cost and distance. However, like most others, although they conceded that some operations require HAPAD, they considered each system against the other rather than using the most cost effective system that met mission requirements. For this reason, this research instead focuses on the appropriate mix of airdrop systems rather than attempting to suggest a best system for all scenarios.

While most research considers the merits of each system separately, likewise most other research also limits the aircraft and locations considered. Limiting the type and number of aircraft artificially limits capacity. Also, as previously stated, the cost of airdrop depends heavily on flying hour cost (which is dependent on aircraft type) and distance (which is dependent on the locations defined in the scenario). Furthermore, Beaubien (1997) stated that multiple corridors and aircraft increase flexibility and decrease vulnerability over a drop zone. For these reasons this research considers multiple origins and destinations and all three major air mobility aircraft (C-130, C-17, and C-5).

Stating the Goal

Ideally, this research aims to establish the groundwork for a planning tool that would aid decision makers in determining how to best employ airdrop, including HAPAD, in future operations. As Ireland (2006) recommends, for airdrop to achieve its full potential, doctrine should be changed to support it and planners should be given tools to estimate its limits. However, at the very least, this research should encourage decision makers to reconsider the utility and application of airdrop. As Dilanian et al. (2006) conclude, the greatest single barrier for JPADS to overcome is an apparent cultural bias against airdrop. Furthermore, this research also challenges the airlift capacity suggested by Kirsteatter et al. (2006) including a more detailed analysis of aircraft fleet attributes on airdrop capacity.

The Classic Minimum Cost Network Flow Problem

The minimum cost network flow model discussed in this thesis is a prescriptive optimization model solved with linear programming. More specifically, this research can be classified as a transportation problem as described in Ragsdale (2007).

Nomenclature

A linear program consists of four parts: the parameters, the decision variables, the objective function, and the constraints. Additionally, the decision variables and parameters are commonly indexed by sets (Ragsdale 2007). The parameters are inputs defined before the model is implemented, the decision variables are the output determined by the model, the objective function represents the goal of the decision maker, and the constraints are the requirements or limitations that must be satisfied (Ragsdale 2007).

In the transportation problem I and J are the sets of origins and destinations, respectively. The decision variables are in the form V_{ij}, which is the amount shipped from origin $i \in I$ to destination $j \in J$ (where "$\in$" means "an element of the set"). The parameters are likewise in the form C_{ij}, which is the cost per unit to ship from origin $I \in I$ to destination $j \in J$. Parameters such as S_i and D_j may also be defined describing the supply and demand at each origin $i \in I$ and destination $j \in J$ (Ragsdale 2007).

Network Representation

Network flow problems can be illustrated graphically by nodes connected by directed arcs. The nodes are origins and destinations with supply and demand. The directed arcs show the valid paths and directions of flow between nodes, usually including their associated costs. The transportation problem is a specialized type of network flow problem in which there are no intermediary transshipment nodes as pictured in Figure 1 (Ragsdale 2007).

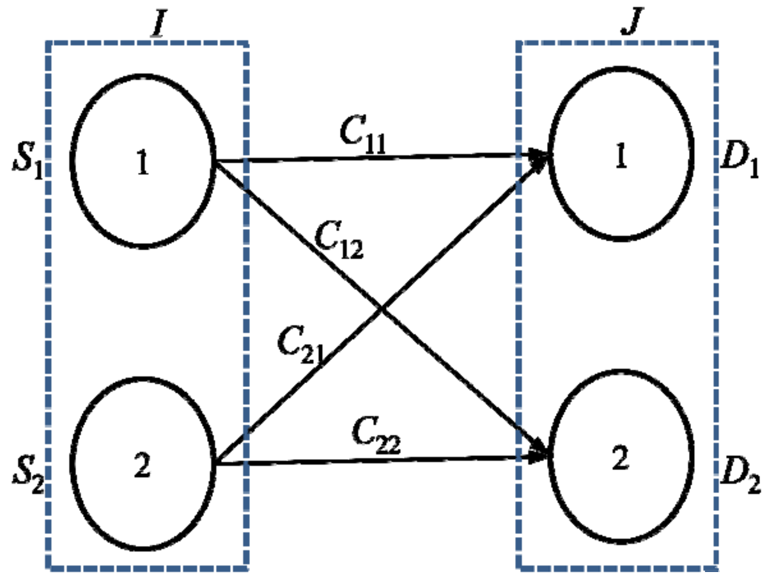

Figure 1. Transportation Model Network

Objective Function and Constraints

The objective function of the network flow problem is stated as a linear combination of each decision variable multiplied by its corresponding cost parameter. As the name indicates, the goal is to minimize the value of that function, which minimizes the cost of all shipments between all nodes. Mathematically this is stated as Minimize $\Sigma_i\Sigma_j C_{ij} V_{ij}$ (Ragsdale 2007).

In the classic network flow problem the only constraints are with balance-of-flow and nonnegativity. In other words, the total amount received at demand nodes cannot exceed the total amount available at the supply nodes and there can be no shipments of negative value. Mathematically, these are stated as inequalities. For example, if S_i represents the supply at node i then $\Sigma_j V_{ij} \leq S_i$ and $V_{ij} \geq 0$ for all $i \in I$ and $j \in J$ (Ragsdale 2007).

Vector

This chapter has briefed the history of the problem and the state-of-the art in addressing the problem. The next chapter describes a methodology to improve on the current state-of-the-art.

III. Methodology

Overview

This chapter describes a model (termed the *airdrop model*) and methodology to address the research objective stated in Chapter I by expanding the basic transportation minimum cost network flow model (discussed in Chapter II) to encompass the airdrop problem. Then the chapter discusses how the model is implemented for three scenarios.

Formulating the Model

As alluded to in the previous chapters, the *airdrop model* includes multiple aircraft and airdrop types traveling between multiple origins and destinations which incur a monetary cost. In this model, the airdrop types are more specifically referred to as paradrop types, the origins are referred to as embarkation origins and the destinations are referred to as destination drop zones. Additionally, supply at each embarkation origin is in terms of sorties available while demand at each destination drop zone is in cargo weight so a conversion for weight per sortie must be incorporated. Also, the *airdrop model* will consider the accuracy, altitude, and offset limitations and capabilities of each destination drop zone and paradrop type.

Nomenclature

The *airdrop model* presented in this chapter employs the nomenclature listed in Table 1. In this table recall $\in$ means "an element of the set". Specific values for the sets, parameters, and variables depend on the scenario being considered.

Table 1: *Airdrop Model* Nomenclature.

Nomenclature	Description
Sets:	
$A = \{a_1, a_2, \ldots a_\alpha\}$	Aircraft types
$P = \{p_1, p_2, \ldots p_\pi\}$	Paradrop types
$E = \{e_1, e_2, \ldots e_\varepsilon\}$	Embarkation origins
$D = \{d_1, d_2, \ldots d_\delta\}$	Destination drop zones
Parameters:	
C_{aped}	Cost per sortie by aircraft $a \in A$ and paradrop type $p \in P$ per embarkation origin $e \in E$ to destination drop zone $d \in D$
R_d	Sustainment weight requirement for destination drop zone $d \in D$ i.e. the demand at destination drop zone $d \in D$
Q_{ae}	Available sorties of aircraft type $a \in A$ at embarkation origin $e \in E$
W_{ap}	Sortie weight for aircraft $a \in A$ and paradrop type $p \in P$
M_d	Accuracy requirement for destination drop zone $d \in D$
F_d	Deployment altitude requirement for destination drop zone $d \in D$
O_d	Offset requirement for destination drop zone $d \in D$
X_p	Accuracy capability for paradrop type $p \in P$
Y_p	Deployment altitude capability for paradrop type $p \in P$
Z_p	Offset capability for paradrop type $p \in P$
Variables:	
S_{aped}	Sortie rate by aircraft $a \in A$ and paradrop type $p \in P$ per embarkation origin $e \in E$ to destination drop zone $d \in D$
B_{pd}	Binary values by destination drop zone $d \in D$ and paradrop type $p \in P$ i.e. if paradrop type capabilities (X_p, Y_p, Z_p) meet destination drop zone requirements (M_d, F_d, O_d) then $B_{pd} = 1$, otherwise $B_{pd} = 0$

Network Representation

Adjacent, in Figure 2, the airdrop model for a scenario with three embarkation origins and four destination drop zones is illustrated graphically according to the convention described previously (see Figure 1) in

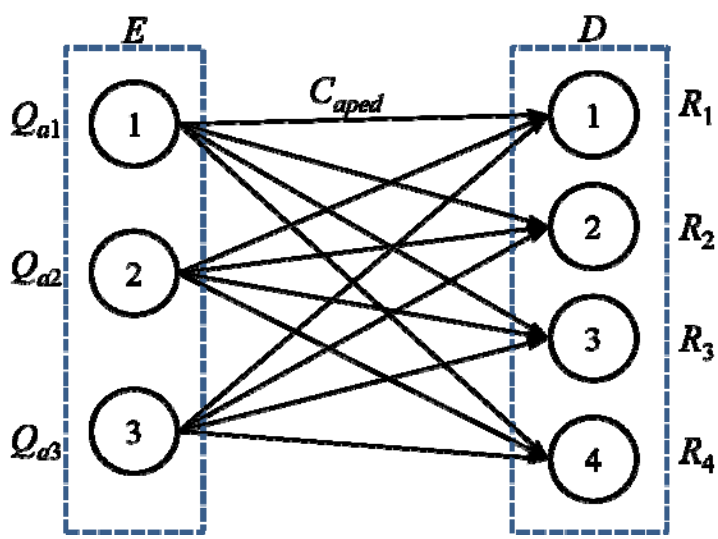

Figure 2. Simplified Airdrop Model Network

which the embarkation origins are the supply nodes and the destination drop zones are the demand nodes connected by directed arcs representing flow of aircraft. There is one arc for each aircraft and paradrop type combination; therefore, this illustration represents one aircraft and paradrop type shipping between three embarkation origins and four destination drop zones. To include four aircraft and six paradrop types, 24 arcs between each embarkation origin and each destination drop zone would be required.

Objective Function and Constraints

The objective function for the *airdrop model* follows the form of the minimum cost transportation network flow problem mentioned previously; however it is somewhat more detailed:

$$Min: \sum_{a \in A} \sum_{p \in P} \sum_{e \in E} \sum_{d \in D} C_{aped} S_{aped}$$

This equation describes the minimum cost for all sorties by all aircraft and paradrop types between all embarkation origins and destination drop zones.

True to most modeling, the challenge is in accurately capturing all the necessary constraints. This model assumes total supply exceeds total demand. Given that airlift capacity now is much greater than it was during the Berlin airlift, the question isn't how much can we support, it is how much will it cost. Therefore, this research assumes priority will dictate that resources are made available in sufficient quantity to satisfy the mission. When making this assumption, according to Ragsdale (2007), balance-of-flow dictates that inflow minus outflow must be greater than or equal to supply or demand for each node. In other words, the amount shipped from each embarkation origin must not exceed the supply for each origin so Q_{ae} serves as an upper bound on S_{aped} (again, "∈" means "an element of the set" and "∀" means "for all"):

$$\sum_{p \in P} \sum_{d \in D} S_{aped} \leq Q_{ae} \forall\, a \in A, e \in E$$

Likewise the amount shipped to each destination drop zone must meet the sustainment weight requirement and, because flow is in terms of sorties while demand is in terms of weight, the weight conversion parameter W_{ap} must be multiplied by the number of sorties. This yields the constraints:

$$\sum_{a \in A} \sum_{p \in P} \sum_{e \in E} S_{aped} W_{ap} \geq R_d \forall\, d \in D$$

Non-negativity constraints serve as lower bounds, since there can be no negative sortie flow, and hence:

$$S_{aped} \geq 0 \;\forall a \in A, p \in P, e \in E, d \in D$$

The *airdrop model* also incorporates a set of constraints which are side constraints to the minimum cost transportation network flow problem. Each paradrop type has capabilities in terms of deployment altitude, accuracy, and offset. The paradrop deployment altitude describes the maximum altitude from which the bundle can be deployed. Paradrop accuracy describes how close to the intended IP that the bundle will land. Paradrop offset describes the maximum distance from the intended IP from which the bundle can be deployed. There are corresponding drop zone requirements. Drop zone altitude refers to the minimum allowable deployment altitude for the IP. Drop zone accuracy describes the drop zone size identifying the maximum allowable distance from the IP. Drop zone offset refers to the minimum distance from the intended IP from which the bundle can be deployed. The side constraints dictate that paradrop type capabilities must meet drop zone requirements. If they do not then there can be no sorties of the paradrop type to the destination drop zone:

If $X_p > M_d \; \forall \; d \in D, \; p \in P$ then $S_{aped} = 0$

If $Y_p < F_d \; \forall \; d \in D, \; p \in P$ then $S_{aped} = 0$

If $Z_p > O_d \; \forall \; d \in D, \; p \in P$ then $S_{aped} = 0$

The final set of constraints are linking constraints which establish the relationship between the side constraints and the decision variables by incorporating binary variables and an upper bound, which Ragsdale refers to as the "Big M" (2007). The binary variables (B_{pd}) are used to enforce the side constraints for destination drop zone accuracy, altitude, and offset requirements. By definition, binary variables have the value of zero or one. If the paradrop type capabilities meet the destination drop zone requirements the binary variable value is one, if not it is zero. Logically, these conditions can be stated:

If $M_d \leq X_p \; \forall \; d \in D, \; p \in P$ then $B_{pd} = 1 \; \forall \; d \in D, \; p \in P$, if not $B_{pd} = 0 \; \forall d \in D, \; p \in P$

If $F_d \leq Y_p \; \forall \; d \in D, \; p \in P$ then $B_{pd} = 1 \; \forall \; d \in D, \; p \in P$, if not $B_{pd} = 0 \; \forall d \in D, \; p \in P$

If $O_d \geq Z_p \; \forall \; d \in D, \; p \in P$ then $B_{pd} = 1 \; \forall \; d \in D, \; p \in P$, if not $B_{pd} = 0 \; \forall d \in D, \; p \in P$

The same statements are enforced mathematically by the following expressions:

$$B_{pd} \leq (X_p - M_d) + 1 \; \forall d \in D, \; p \in P$$

$$B_{pd} \leq (Y_p - F_d) + 1 \; \forall d \in D, \; p \in P$$

$$B_{pd} \leq (Z_p - O_d) + 1 \; \forall d \in D, \; p \in P$$

In the *airdrop model* the "Big M" is actually U. The value of U is dependent on the scenario and should be chosen to represent logical upper bounds on the decision variables which will not impede the optimal solution (Ragsdale 2007). For the scenarios described later the value of *U* is 1000. The link then states that the value of the sortie decision variables must be less than or equal to the value of the binary variables multiplied by *U*:

$$S_{aped} \leq UB_{pd} \; \forall \; p \in P, d \in D$$

To summarize, the *airdrop model* is expressed mathematically by the following statements:

Minimize:

$$\sum_{a \in A} \sum_{p \in P} \sum_{e \in E} \sum_{d \in D} C_{aped} S_{aped}$$

Subject to:

$$\sum_{p \in P} \sum_{d \in D} S_{aped} \leq Q_{ae} \forall \; a \in A, e \in E$$

$$\sum_{a \in A} \sum_{p \in P} \sum_{e \in E} S_{aped} W_{ap} \geq R_d \forall \; d \in D$$

$$S_{aped} \leq UB_{pd} \; \forall \; p \in P, d \in D$$

$$B_{pd} \leq (X_p - M_d) + 1 \; \forall d \in D, p \in P$$

$$B_{pd} \leq (Y_p - F_d) + 1 \; \forall d \in D, p \in P$$

$$B_{pd} \leq (Z_p - O_d) + 1 \; \forall d \in D, p \in P$$

$$S_{aped} \geq 0 \; \forall a \in A, p \in P, e \in E, d \in D$$

B_{pd} must be binary $\forall \; p \in P, d \in D$

Implementing the Model

The *airdrop model* was implemented with the following sets, parameters, and variables for all scenarios unless otherwise specified in the particular scenario description. The specific parameter values not listed below are provided in Appendix D. The model for all scenarios was run on Microsoft Office Excel 2007 with Frontline Systems Premium Solver Version 8.0 using the "Standard LP/Quadratic" setting.

Sets

The aircraft types included are the C-130, C130J, C-17, and C-5, therefore A = {C130, C130J, C17, C5}. The paradrop types included are 10K CAD, 2K PBA, 10K PBA, 2K PGA, 10K PGA, and 30K PGA, therefore P = {10KCAD, 2KPBA, 10KPBA, 2KPGA, 10KPGA, 30PGA}. There are three embarkation origins (E = {Ramstein AB, Dover AFB, Travis AFB}) and four destination drop zones ($D = \{d_1, d_2, d_3, d_4\}$) as specified in the scenario descriptions later.

Parameters

Sortie cost (C_{aped}) includes the combined cost of an aircraft load of the paradrop type and the round trip flying hour cost of the sortie (it does not include the cargo cost itself). Paradrop type costs were provided by the USA Natick Soldier Center (Martin 2008). Aircraft load capacity for each paradrop type describes the number of bundles of each paradrop type that each aircraft type can carry considering both the weight and volume capacities of the aircraft. Basically, the rigged weight of each paradrop type bundle (as opposed to the payload weight) was divided into the cargo weight allowance of the aircraft type and rounded down. Similarly, for volume, the floor space in the cargo cabin of each aircraft type was compared against the footprint of each paradrop type bundle. The aircraft type capacity of each paradrop type is the lower of either the weight or volume capacity. The Air Mobility Command (AMC) Airlift/Airdrop Branch provided values for C-130, C-130J, and C-17 aircraft using the aircrafts maximum allowable cabin load (ACL) as the weight limit (Fields 2007). Values for C-5 aircraft were not available because they are not currently used for airdrop so C-5 aircraft values are estimated as twice that of C-17 aircraft. However, all load capacity values are reduced by a planning load weight capacity of 5/7 of the ACL which is referred to as the "load factor" or abbreviated "load X" in the *airdrop model.* The round trip flying hour cost is the cost per flying hour (CPFH) for each aircraft type multiplied by the round trip flying time (RTFT). This research uses the 2008 CPFH for C-130H, C-130J, C-17A and C-5B as posted by the Office of the Under Secretary of Defense (Reimbursable 2008). Air Mobility Planning Factors lists aircraft speeds as "block speeds" based on distance flown (AFPAM 10-1403 2003). The scenarios define distances from approximately 2,000 to 6,000 miles so those block speeds for each aircraft type were referenced. The value used for each aircraft type speed is the lowest referenced block speed for each aircraft type. Because C-130J figures are not listed, its speed is interpolated by multiplying C-130 block speed by the ratio of C-130 maximum speed and C-130J maximum speed as listed in *Airman Magazine* (Heritage 2007). To figure RTFT for each aircraft, the distance between each embarkation origin and destination drop zone, as listed in the scenario descriptions, was divided by the aircraft type speed. The specific values used for paradrop type costs, aircraft capacity, CPFH, and aircraft speed are listed in Appendix D. Therefore,

$$C_{aped} = \text{(Paradrop Type Cost)(Aircraft Capacity)} + \text{(CPFH)(RTFT)}$$

Destination drop zone requirements for sustainment weight, accuracy, deployment altitude, and offset (R_d, M_d, F_d, O_d) are specified in the scenario descriptions.

Sortie rate supply (Q_{ae}) is operations window divided by the cycle time (CT) multiplied by available fleet size and the queuing efficiency. Because the model is implemented to find a daily sortie rate, the operations window (abbreviated window) is the number of hours per day that operations will be planned. Because the scenarios in this research are high-priority, a 24 hour window was used; however, daytime operations using a 12 hour window or normal shift operations using an 8 hour window may be more appropriate for other scenarios . The CT, as described in Air Mobility Planning Factors, captures how long each sortie takes. It includes round trip ground time (RTGT) as listed in Appendix D, which accounts for loading and unloading the aircraft, added to the RTFT as discussed above (AFPAM 10-1403 2003). Specific CT values are included with the solutions in Appendix E. Available fleet size refers to the number of each aircraft type $a \in A$ that are dedicated to the operation reduced by an 80% mission capable (MC) rate to account for maintenance and repair (as discussed later in Assumptions). Fleet sizes are specified in the scenario descriptions. Finally, Stucker and Williams (1999) suggest airlift capacity should be reduced as much as 20% to account for ground resource shortages and delays. This research accounts for ground delays by incorporating the 85% que efficiency listed in Air Mobility Planning Factors (AFPAM 10-1403 2003). Therefore,

$$Q_{ae} = (\text{Window} \div \text{CT})(\text{Available Fleet Size})(\text{MC})(\text{Que Efficiency})$$

Sortie weight (W_{ap}) is payload weight of the paradrop type multiplied by the aircraft capacity of that paradrop type and reduced by drop loss. Payload weight refers to the actual cargo weight of a bundle not including the paradrop equipment. These values were provided by Natick Soldier Center as listed in Appendix D (Martin 2008). Aircraft capacity is figured the same as described under “sortie cost”. Drop loss accounts for payload survivability. Whereas Varner (2000) considered a range from 80% to 95%, this research used 85% as suggested by Kirsteater et al. (2006). Therefore,

$$W_{ap} = (\text{Paradrop Type Payload Weight})(\text{Aircraft Capacity})(\text{Drop Loss})$$

Paradrop type accuracy, deployment altitude, and offset capabilities (X_p, Y_p, Z_p) are listed in Appendix D as provided by USA Natick Soldier Center (Benney 2007, Martin 2008).

Variables

The sortie rate (S_{aped}) is the output of the model. It is important to emphasize that it is a rate, not a quantity of sorties; therefore, non-integer values are acceptable. This is preferable for several reasons. First of all, the model is less computationally demanding when run without integer constraints. Furthermore, at best, an integer solution can only be as good as the solution without integer constraints (Ragsdale 2007). By running the model without integer constraints for the daily sortie rate cost, it is possible to estimate operation costs and sortie rates for operations of different lengths without re-running the model by simply multiplying by different numbers of days. Obviously, an aircraft cannot fly a fraction of a sortie, but by rounding the number of sorties after the rate is multiplied by the number of operation days, rather than before, a much more accurate estimate is achieved.

The binary variables (B_{pd}) are used to enforce the side constraints for destination drop zone accuracy, altitude, and offset requirements. By definition, binary variables have the value of zero or one. If the paradrop type capabilities meet the destination drop zone requirements, the binary variable value is one, if not it is zero. These values can be preprocessed without affecting optimality because they dictate which paradrop types are not feasible solutions without limiting the model's choice of feasible paradrop types. Therefore, in the implementation of the model the binary variables were preprocessed as discussed previously.

Assumptions

As exemplified by the Berlin airlift, it is assumed the priority of the airdrop mission will influence a decision to consolidate a portion of the mobility fleet to better meet mission requirements. Also, as the 2005 Base Realignment and Closure (BRAC) commission stated, "reduced base operations costs are realized through increased efficiencies inherent in the consolidation of functions on fewer bases" (DOD 2007). The bases chosen as embarkation origins for the scenarios (Dover AFB, Travis AFB, and Ramstein AB) are major mobility aircraft hubs; therefore, they already have a support infrastructure in place and any future BRAC decisions should only serve to make these bases more robust. By choosing bases on each coast and in Europe the fleet is well positioned to meet needs anywhere in the world at short notice.

Distances between drop zones for an intertheatre mission are considered negligible; therefore, the distance between an embarkation origin and all drop zones in one theatre will be the same. Of course, distances between the other embarkation origins and those same drop zones will still be different. Furthermore, the *airdrop model* can account for different distances to every drop zone if that is the case.

Air Force MC rate goals for C-130, C-130J, C-17, and C-5 aircraft are 75, 75, 87.5 and 75%, respectively, with an average of 79.2% (Durden 2008). The scenarios assume aircraft meet the goal with an average 80% rate, which is applied to reduce the effective fleet size chosen for each scenario accounting for maintenance and repair. In fact, the twelve-month average (as of January 2008) for each aircraft type was 74.5, 78.1, 86.1 and 68.6, respectively, making the true MC rate average 76.8 (Durden 2008). However, without C-5 aircraft the MC rate is 79.6 and Lockheed Martin stated the C-5

Avionics Modernization Program (AMP) and the Reliability Enhancement and Re-engining Program (RERP) will allow the C-5 to achieve MC rates of 75 to 85% by 2018, which is the time frame for the scenarios in this research (Tirpak 2004).

To make comparisons between bases balanced, the available fleet is evenly distributed between all three embarkation origins except as noted in the scenario descriptions.

As in Dilanian et al. (2006), flying hour cost figures are assumed to include training costs even for the C-5 aircraft, whose crews are not currently trained for airdrop, as total number of training hours would not increase, only the type of training accomplished. Paradrop equipment costs are calculated both for one time use (to represent no equipment recovery) and life span use ranging from twenty to one hundred uses depending on the system as listed in Appendices D and E.

Aircraft capacities were limited by either floor space or maximum weight as discussed in "Parameters" and listed in Appendix D. The final form of the 30K system is not yet established so this research assumes each 30K system requires approximately three contiguous 10K pallet positions. Because C-5 aircraft are not currently used for airdrop, their capacity is not well defined; therefore, this research assumed C-5 floor space capacity to be twice that of a C-17 limited by C-5 weight capacity. However, to mitigate concerns with this assumption as well as the MC rate stated previously, each scenario was run with and without C-5 aircraft.

Defining the Scenarios

The model implementation discussed above and spreadsheet it went into were designed such that the scenarios need only identify the embarkation origins and destination drop zones (from which distance can be determined), provide the available fleet size of each aircraft type at each embarkation origin, and define the destination drop zones' sustainment weight, accuracy, deployment altitude, and offset requirements.

Scenario 1

The first scenario is built to resemble that of Kirsteatter et al. (2006) with some important differences. They established a Middle Eastern setting in the near future requiring distribution-level amounts of sustainment using an unclassified version of a Defense Planning Scenario (DPS) baseline security posture (BSP) vignette. The mission was counter-insurgency and counter-drug against a force of approximately 20,000 hostiles armed with surface-to-air missiles (SAMs), MANPADS, IEDs and small arms whose main strategies were attacking air and sea ports and main supply routes. The supply requirement for the 45,000 U.S. troops described by the multi-service force data (MSFD) and time-phased force deployment data (TPFDD) of the vignette was calculated using the Operational Logistics (OPLOG) Planner and the Planning Data Branch database at no more than 3,400 short tons (stons) per day. The first scenario in this research incorporates all of these attributes.

The first scenario of this research differs from Kirsteatter et al. (2006) based on several important factors. No airland, sea or convoy activities are used; to avoid attack and terrain obstacles all sustainment is through airdrop. All airdrop is strategic intertheatre; no foreign controlled bases are used. The scenario allocation of aircraft is similar to Kirsteatter et al. (2006) but none are placed intratheatre, and instead were located in Ramstein AB. Four destination drop zones were established with the sustainment requirement evenly split between them and relatively unrestrictive altitude, offset and accuracy requirements as listed in Table 2. This scenario was run four different ways: (1a) includes C-5 aircraft and figures paradrop equipment cost as one time use, (1b) includes C-5 aircraft and figures paradrop equipment cost based on life span uses, (1c) does not include C-5 aircraft and figures paradrop equipment cost as one time use, and (1d) does not include C-5 aircraft and figures paradrop equipment cost based on life span uses.

Table 2: Scenario 1a Data

Destination Drop Zone Requirements					Embarkation Origin Data					
DZ	Stons	Altitude	Offset	Accuracy	Origin	Distance to DZ	Available Fleet			
							C130	C130J	C17	C5
D1	850	800	0	2500						
D2	850	800	0	2500	Dover	6,140	0	0	0	0
D3	850	8000	0	2500	Travis	7,440	0	0	0	0
D4	850	800	0	500	Ramstein	2,190	65	0	40	15

Table 2 lists destination drop zone requirements by drop zone including sustainment weight requirement in short tons, deployment altitude requirement in feet above ground level (AGL), and accuracy requirement in meters from IP. Embarkation origin data is also listed including the distance in miles from each embarkation origin to the theatre the drop zones are in and the number of each aircraft type at each embarkation origin. The information in Table 2 would be the same for Scenario 1b. For Scenarios 1c and 1d the information in Table 2 would be the same except the “C5” column would be all zeros.

Scenario 2

Scenario 2 considers a similar environment as scenario 1, but on a much larger scale. In September 2007 there were 169,000 U.S. troops in Iraq when the Defense Secretary announced a goal to cut the troop level to 100,000 by December 2008 (Defense

2007). This scenario incorporates a comparable figure of 135,000 troops, three times that of the first scenario, with a sustainment weight requirement also three times the first scenario; again, evenly split between four destination drop zones. Altitude, offset and accuracy requirements are listed in Table 3. For this mission, similar to the Berlin airlift, priority will dictate the consolidation of half the mobility fleet evenly between the three embarkation origins. Scenario 2 is considered with the same four variations (a, b, c, d) described for the first scenario.

Table 3: Scenario 2a Data

Destination Drop Zone Requirements					Embarkation Origin Data					
							Available Fleet			
DZ	Stons	Altitude	Offset	Accuracy	Origin	Distance to DZ	C130	C130J	C17	C5
D1	2550	800	0	2500						
D2	2550	16000	8	300	Dover	6,140	60	4	62	43
D3	2550	8000	0	1000	Travis	7,440	60	4	62	43
D4	2550	800	0	500	Ramstein	2,190	60	4	62	43

Table 3 lists destination drop zone requirements by drop zone including sustainment weight requirement in short tons, deployment altitude requirement in feet AGL, and accuracy requirement in meters from IP. Embarkation origin data is also listed including the distance in miles from each embarkation origin to the theatre the drop zones are in and the number of each aircraft type at each embarkation origin. The information in Table 3 would be the same for Scenario 2b. For Scenarios 2c and 2d the information in Table 3 would be the same except the “C5” column would be all zeros.

Scenario 3

Scenario 3 includes the same Middle Eastern operation described in scenario 2 but also includes a Far Eastern operation. In February 2008 there were 28,500 U.S. troops in South Korea. This scenario incorporates a comparable figure of 45,000 troops as in scenario 1 with the same sustainment weight requirement. To address these missions, essentially, the model will be run twice with Dover AFB and Ramstein AB assigned to support the Mid-East and Travis AFB assigned to support the Far East. Destination drop zone requirements and embarkation origin data are listed in Table 4. For this scenario variations a, b, c, and d are the same as in scenario 1 and 2 for the Mid-East operation while variations e, f, g, and h reflect the same adjustments respectively for the Far East operation.

Table 4: Scenario 3a and 3e Data

Mid Eastern Operation										
Destination Drop Zone Requirements					Embarkation Origin Data					
DZ	Stons	Altitude	Offset	Accuracy	Origin	Distance	Available Fleet			
D1	2550	800	0	2500		to DZ	C130	C130J	C17	C5
D2	2550	16000	8	300	Dover	6,140	60	4	62	43
D3	2550	8000	0	1000	Travis	7,440	0	0	0	0
D4	2550	800	0	500	Ramstein	2,190	60	4	62	43
Far Eastern Operation										
Destination Drop Zone Requirements					Embarkation Origin Data					
DZ	Stons	Altitude	Offset	Accuracy	Origin	Distance	Available Fleet			
D1	850	800	0	2500		to DZ	C130	C130J	C17	C5
D2	850	16000	8	300	Dover	6,940	0	0	0	0
D3	850	8000	0	1000	Travis	5,600	60	4	62	43
D4	850	800	0	500	Ramstein	5,350	0	0	0	0

Table 4 lists destination drop zone requirements by drop zone including sustainment weight requirement in short tons, deployment altitude requirement in feet AGL, and accuracy requirement in meters from IP. Embarkation origin data is also listed including the distance in miles from each embarkation origin to the theatre the drop zones are in and the number of each aircraft type at each embarkation origin. The information in Table 4 would be the same for Scenarios 3b and 3f. For the remaining scenarios, the information in Table 4 would be the same except the "C5" column would be all zeros.

Vector

This chapter has described the technique used to address the research objective. The next chapter describes the results of the application of the technique.

IV. Results and Analysis

Overview

The first half of this chapter presents a summary of the *airdrop model* solutions to the scenarios described in Chapter III. The complete solved spreadsheet models are included in Appendix E. Included with each airdrop solution summary is a convoy comparison. A description of the equations for those comparisons is included below. This chapter also makes an analysis of paradrop and aircraft types by viewing the results collectively and closes by including other considerations for alternative supply method comparisons.

Convoy Equivalent

The United States Transportation Command description of a medium convoy includes 10 vehicles and 23 personnel with a capacity of 14,000 pounds. This includes three security vehicles with three personnel each and seven cargo vehicles with two personnel each. Based on these figures AMC/A3D calculates every C-130 aircraft with seven CDS bundles keeps one convoy off the road (McGee 2007). In similar fashion, this research calculates every 14,000 pounds delivered by airdrop replaces one medium convoy composed of 10 vehicles and 23 personnel; in other words, seven short tons is one convoy equivalent.

Airdrop Solutions with Convoy Comparisons

A summary of each airdrop solution for each scenario described in Chapter III is listed in the following section. A convoy equivalent, as described above, is included with each solution. Again, the complete solved airdrop model spreadsheet for each scenario is included in Appendix E. When referring to the spreadsheet, embarkation origins are, in places, abbreviated as origin A, B, and C for Dover AFB, Travis AFB and Ramstein AB, respectively. Also, the only element on the spreadsheet not yet discussed is the “Max Stons” matrix. This matrix was created to estimate the maximum feasible airdrop capacity. It was calculated by multiplying highest sortie payload capacity for each aircraft type by the sorties available for that aircraft type from each embarkation origin. The sum of these figures may not represent the true airdrop capacity because destination drop zone requirements may dictate that the paradrop type with the highest sortie payload is not an option; however, they do provide a useful upper bound on the airdrop capacity.

Scenario 1

As discussed in Chapter III, this scenario was run four different ways: (1a) includes C-5 aircraft and figures paradrop equipment cost as one time use, (1b) includes C-5 aircraft and figures paradrop equipment cost based on life span uses, (1c) does not include C-5 aircraft and figures paradrop equipment cost as one time use, and (1d) does not include C-5 aircraft and figures paradrop equipment cost based on life span uses. A summary of the *airdrop model* solutions is provided in Tables 5, 6, 7 and 8. The “Max Stons” matrix identified that supplying 3,400 stons without C-5 aircraft was infeasible; however, the model could solve for 2,900 stons as detailed in Tables 7 and 8.

Table 5: Scenario 1a Airdrop Solution Summary

Sorties by Paradrop Type & Destination Dropzone				
	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	0.00	0.00
10K PBA	18.52	18.52	15.41	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	0.00	0.00	0.00
30K PGA	0.00	0.00	0.00	21.79

Sorties by Aircraft Type & Embarkation Origin				
	C130	C130J	C17	C5
Dover	0.0	0.0	0.0	0.0
Travis	0.0	0.0	0.0	0.0
Ramstein	11.1	0.0	47.1	16.1

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
3,400	486	30,194,296.00

Table 5 summarizes the solution for scenario 1a in Appendix E by listing the daily sortie rate by both paradrop type to each destination drop zone and aircraft type from each embarkation origin. Note that the C-17 and C-5 aircraft sortie supply was exhausted, forcing the model to include C-130 aircraft to meet the requirement. Recall that drop zone 4 had the most demanding accuracy requirement, which was the only drop zone that used 30K PGA rather than 10K PBA. Also listed is the daily stons supplied, the convoy equivalent representing the number of medium convoys required daily to supply an equivalent weight, and the airdrop operation cost in dollars per day.

Table 6: Scenario 1b Airdrop Solution Summary

Sorties by Paradrop Type & Destination Dropzone				
	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	9.89	0.00
10K PBA	16.37	18.52	15.91	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	0.00	0.00	12.38
30K PGA	0.00	0.00	0.00	0.00

Sorties by Aircraft Type & Embarkation Origin				
	C130	C130J	C17	C5
Dover	0.0	0.0	0.0	0.0
Travis	0.0	0.0	0.0	0.0
Ramstein	9.9	0.0	47.1	16.1

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
3,400	486	12,529,297.00

Table 6 summarizes the solution for scenario 1b in Appendix E by listing the daily sortie rate by both paradrop type to each destination drop zone and aircraft type from each embarkation origin. Again, the C-17 and C-5 aircraft sortie supply was exhausted, forcing the model to include C-130 aircraft to meet the requirement. Recall that cargo weight per sortie depends on both paradrop and aircraft type. In this case, although drop zone 4 only receives 12.38 10K PGA sorties per day, they are by C-5 (as detailed in Appendix E); therefore, the weight requirement is still met. Furthermore, as the only difference between this scenario and the last is in figuring paradrop type cost for lifespan use rather than single use, this solution demonstrates how that change impacts not only the airdrop operation cost per day but also the aircraft and paradrop types that comprise the optimum solution. Also listed is the daily stons supplied, the convoy equivalent representing the number of medium convoys required daily to supply an equivalent weight, and the airdrop operation cost in dollars per day.

Table 7: Scenario 1c Airdrop Solution Summary

Sorties by Paradrop Type & Destination Dropzone				
	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	5.78	0.00	0.00	0.00
10K PBA	14.27	15.80	15.80	0.00
2K PGA	0.00	0.00	0.00	58.39
10K PGA	0.00	0.00	0.00	1.27
30K PGA	0.00	0.00	0.00	0.00

Sorties by Aircraft Type & Embarkation Origin				
	C130	C130J	C17	C5
Dover	0.0	0.0	0.0	0.0
Travis	0.0	0.0	0.0	0.0
Ramstein	64.2	0.0	47.1	0.0

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
2,900	415	48,540,569.00

Table 7 summarizes the solution for scenario 1c in Appendix E by listing the daily sortie rate by both paradrop type to each destination drop zone and aircraft type from each embarkation origin. In this solution there are no C-5 aircraft available and C-17 and C-130 aircraft sortie supply was exhausted with only 2,900 stons supplied per day rather than the 3,400 stons required. Note, without C-5 aircraft, this solution does not include 30K PGA as in scenario 1a. Also listed is the daily stons supplied, the convoy equivalent representing the number of medium convoys required daily to supply an equivalent weight, and the airdrop operation cost in dollars per day.

Table 8: Scenario 1d Airdrop Solution Summary

Sorties by Paradrop Type & Destination Dropzone				
	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	5.78	0.00	0.00	0.00
10K PBA	14.27	15.80	15.80	0.00
2K PGA	0.00	0.00	0.00	58.39
10K PGA	0.00	0.00	0.00	1.27
30K PGA	0.00	0.00	0.00	0.00

Sorties by Aircraft Type & Embarkation Origin				
	C130	C130J	C17	C5
Dover	0.0	0.0	0.0	0.0
Travis	0.0	0.0	0.0	0.0
Ramstein	64.2	0.0	47.1	0.0

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
2,900	415	14,068,405.00

Table 8 summarizes the solution for scenario 1d in Appendix E by listing the daily sortie rate by both paradrop type to each destination drop zone and aircraft type from each embarkation origin. It is interesting that without C-5 aircraft the same aircraft and paradrop types were selected regardless if paradrop type was figured for single use or lifetime use (compare table 7 and table 8). Also listed is the daily stons supplied, the convoy equivalent representing the number of medium convoys required daily to supply an equivalent weight, and the airdrop operation cost in dollars per day.

Scenario 2

As discussed in Chapter III, this scenario was also run four different ways: (2a) includes C-5 aircraft and figures paradrop equipment cost as one time use, (2b) includes C-5 aircraft and figures paradrop equipment cost based on life span uses, (2c) does not include C-5 aircraft and figures paradrop equipment cost as one time use, and (2d) does not include C-5 aircraft and figures paradrop equipment cost based on life span uses. A summary of the *airdrop model* solutions is provided in Tables 9, 10, 11 and 12. Again the “Max Stons” matrix identified that supplying full cargo weight requirement, in this case 10,200 stons, without C-5 aircraft was infeasible; however, the model could solve for 7,300 stons as detailed in Tables 11 and 12.

Table 9: Scenario 2a Airdrop Solution Summary

Sorties by Paradrop Type & Destination Dropzone	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	118.66	0.00
10K PBA	55.56	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	0.00	0.00	9.98
30K PGA	0.00	37.74	0.00	31.33

Sorties by Aircraft Type & Embarkation Origin	C130	C130J	C17	C5
Dover	0.0	0.0	34.3	23.0
Travis	0.0	0.0	13.3	0.0
Ramstein	59.2	4.3	73.0	46.0

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
10,200	1,458	156,080,124.00

Table 9 summarizes the solution for scenario 2a in Appendix E by listing the daily sortie rate by both paradrop type to each destination drop zone and aircraft type from each embarkation origin. This solution well illustrates the impact of distance on cost. The sortie supply for all aircraft types at Ramstein AB were exhausted as were the C-17 and C-5 sortie supplies at Dover AFB. However, C-17 aircraft from Travis AFB were used before C-130 aircraft from Dover AFB. Also listed is the daily stons supplied, the convoy equivalent representing the number of medium convoys required daily to supply an equivalent weight, and the airdrop operation cost in dollars per day.

Table 10: Scenario 2b Airdrop Solution Summary

Sorties by Paradrop Type & Destination Dropzone	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	63.54	0.00
10K PBA	35.09	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	53.17	38.59	58.82
30K PGA	0.00	0.00	0.00	0.00

Sorties by Aircraft Type & Embarkation Origin	C130	C130J	C17	C5
Dover	0.0	0.0	34.3	3.0
Travis	0.0	0.0	29.3	0.0
Ramstein	59.2	4.3	73.0	46.0

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
10,200	1,458	61,974,623.00

Table 10 summarizes the solution for scenario 2b in Appendix E by listing the daily sortie rate by both paradrop type to each destination drop zone and aircraft type from each embarkation origin. Again, the sortie supply of all aircraft types from

Ramstein AB were exhausted as is the C-17 supply at Dover AFB. However, in this case the C-5 supply from Dover AFB is not exhausted in favor of more C-17 aircraft from Travis indicating, noted previously, that figuring paradrop type cost for life span use instead of for single use affects only the airdrop operation cost but also the paradrop and aircraft type in the optimum solution. Also listed is the daily stons supplied, the convoy equivalent representing the number of medium convoys required daily to supply an equivalent weight, and the airdrop operation cost in dollars per day.

Table 11: Scenario 2c Airdrop Solution Summary

Sorties by Paradrop Type & Destination Dropzone				
	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	119.50	0.00
10K PBA	39.76	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	42.10	5.24	42.10
30K PGA	0.00	0.00	0.00	0.00

Sorties by Aircraft Type & Embarkation Origin				
	C130	C130J	C17	C5
Dover	24.6	1.8	34.3	0.0
Travis	20.6	1.5	29.3	0.0
Ramstein	59.2	4.3	73.0	0.0

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
7,300	1,043	134,261,331.00

Table 11 summarizes the solution for scenario 2c in Appendix E by listing the daily sortie rate by both paradrop type to each destination drop zone and aircraft type from each embarkation origin. Note , without C-5 aircraft the sortie supply rate for all remaining aircraft types from all embarkation origins was exhausted but only 7,300 stons per day is supplied rather than the 10,200 stons required. Also listed is the daily stons supplied, the convoy equivalent representing the number of medium convoys required daily to supply an equivalent weight, and the airdrop operation cost in dollars per day.

Table 12: Scenario 2d Airdrop Solution Summary

Sorties by Paradrop Type & Destination Dropzone				
	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	105.26	0.00
10K PBA	39.76	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	42.10	12.69	42.10
30K PGA	0.00	0.00	0.00	0.00

Sorties by Aircraft Type & Embarkation Origin				
	C130	C130J	C17	C5
Dover	24.6	1.8	34.3	0.0
Travis	15.3	0.0	29.3	0.0
Ramstein	59.2	4.3	73.0	0.0

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
7,300	1,043	56,983,238.00

Table 12 summarizes the solution for scenario 2d in Appendix E by listing the daily sortie rate by both paradrop type to each destination drop zone and aircraft type from each embarkation origin. It is interesting in this solution that, when paradrop type cost is figured for lifespan rather than single use, 10K PGA is favored slightly more and 2K PBA slightly less than in the previous solution. Also listed is the daily stons supplied, the convoy equivalent representing the number of medium convoys required daily to supply an equivalent weight, and the airdrop operation cost in dollars per day.

Scenario 3

As discussed in Chapter III, this scenario was run eight different ways as four pairs of solutions: 3a, 3b, 3c and 3d refer to the Middle Eastern setting; 3e, 3f, 3g and 3h refer to the Far Eastern Setting. Similar to Scenario 1 and Scenario 2, (3a) and (3e) include C-5 aircraft and figure paradrop equipment cost as one time use, (3b) and (3f) include C-5 aircraft and figure paradrop equipment cost based on life span uses, (3c) and (3g) do not include C-5 aircraft and figure paradrop equipment cost as one time use, and (3d) and (3h) do not include C-5 aircraft and figures paradrop equipment cost based on life span uses. A summary of the *airdrop model* solutions is provided in Tables 13, 14, 15 and 16. Again, the "Max Stons" matrix identified that supplying full cargo weight requirement (10,200 stons in the Middle East and 3,400 stons in the Far East) without C-5 aircraft was infeasible; however, the model could solve for 5,800 stons and 1,900 stons (respectively) as detailed in Table 15 and 16.

Table 13: Scenario 3a and 3e Airdrop Solution Summary

Middle East

Sorties by Paradrop Type & Destination Dropzone	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	94.17	0.00
10K PBA	55.56	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	51.84	0.00	0.00
30K PGA	0.00	4.48	0.00	37.74

Sorties by Aircraft Type & Embarkation Origin	C130	C130J	C17	C5
Dover	3.8	0.0	34.3	23.0
Travis	0.0	0.0	0.0	0.0
Ramstein	59.2	4.3	73.0	46.0

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
10,200	1,458	157,300,942.00

Far East

Sorties by Paradrop Type & Destination Dropzone	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	20.61	0.00
10K PBA	18.52	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	18.51	0.00	0.00
30K PGA	0.00	0.70	0.00	12.58

Sorties by Aircraft Type & Embarkation Origin	C130	C130J	C17	C5
Dover	0.0	0.0	0.0	0.0
Travis	9.2	0.0	37.0	24.7
Ramstein	0.0	0.0	0.0	0.0

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
3,400	486	64,664,882.00

Table 13 summarizes the solution for scenarios 3a and 3e in Appendix E by listing the daily sortie rate by both paradrop type to each destination drop zone and aircraft type from each embarkation origin. Note sortie supply is not exhausted yet weight requirements are met and primary drivers for paradrop type selection are altitude, offset, and accuracy requirements. Also listed is the daily stons supplied, the convoy equivalent representing the number of medium convoys required daily to supply an equivalent weight, and the airdrop operation cost in dollars per day.

Table 14: Scenario 3b and 3f Airdrop Solution Summary

Middle East

Sorties by Paradrop Type & Destination Dropzone

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	63.54	0.00
10K PBA	35.09	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	46.30	34.68	58.82
30K PGA	0.00	0.00	0.00	0.00

Sorties by Aircraft Type & Embarkation Origin

	C130	C130J	C17	C5
Dover	0.0	0.0	34.3	21.5
Travis	0.0	0.0	0.0	0.0
Ramstein	59.2	4.3	73.0	46.0

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
10,200	1,458	63,560,258.00

Far East

Sorties by Paradrop Type & Destination Dropzone

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	4.2	0.00
10K PBA	18.52	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	12.38	11.64	19.20
30K PGA	0.00	0.00	0.00	0.00

Sorties by Aircraft Type & Embarkation Origin

	C130	C130J	C17	C5
Dover	0.0	0.0	0.0	0.0
Travis	4.2	0.0	37.0	24.7
Ramstein	0.0	0.0	0.0	0.0

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
3,400	486	32,865,856.00

Table 14 summarizes the solution for scenarios 3b and 3f in Appendix E by listing the daily sortie rate by both paradrop type to each destination drop zone and aircraft type from each embarkation origin. Note 10K PGA rates are much higher when paradrop type costs are figured for lifespan rather than single use as listed in Table 13. Also listed is the daily stons supplied, the convoy equivalent representing the number of medium convoys required daily to supply an equivalent weight, and the airdrop operation cost in dollars per day.

Table 15: Scenario 3c and 3g Airdrop Solution Summary

Middle East				
Sorties by Paradrop Type & Destination Dropzone				
	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	92.23	0.00
10K PBA	31.59	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	33.45	6.61	33.45
30K PGA	0.00	0.00	0.00	0.00

Sorties by Aircraft Type & Embarkation Origin				
	C130	C130J	C17	C5
Dover	24.6	1.8	34.3	0.0
Travis	0.0	0.0	0.0	0.0
Ramstein	59.2	4.3	73.0	0.0

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
5,800	829	99,083,392.00

Far East				
Sorties by Paradrop Type & Destination Dropzone				
	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	31.27	0.00
10K PBA	10.35	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	10.96	0.00	10.96
30K PGA	0.00	0.00	0.00	0.00

Sorties by Aircraft Type & Embarkation Origin				
	C130	C130J	C17	C5
Dover	0.0	0.0	0.0	0.0
Travis	26.5	0.0	37.0	0.0
Ramstein	0.0	0.0	0.0	0.0

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
1,900	272	38,665,771.00

Table 15 summarizes the solution for scenarios 3c and 3g in Appendix E by listing the daily sortie rate by both paradrop type to each destination drop zone and aircraft type from each embarkation origin. Again, when C-5 aircraft are not available weight requirement cannot be met and 30K PGA is not used. Also listed is the daily stons supplied, the convoy equivalent representing the number of medium convoys required daily to supply an equivalent weight, and the airdrop operation cost in dollars per day.

Table 16: Scenario 3d and 3h Airdrop Solution Summary

Middle East

Sorties by Paradrop Type & Destination Dropzone

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	87.82	0.00
10K PBA	31.59	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	33.45	8.91	33.45
30K PGA	0.00	0.00	0.00	0.00

Sorties by Aircraft Type & Embarkation Origin

	C130	C130J	C17	C5
Dover	24.3	0.0	34.3	0.0
Travis	0.0	0.0	0.0	0.0
Ramstein	59.2	4.3	73.0	0.0

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
5,800	829	37,728,347.00

Far East

Sorties by Paradrop Type & Destination Dropzone

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	22.15	0.00
10K PBA	10.35	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	10.96	4.77	10.96
30K PGA	0.00	0.00	0.00	0.00

Sorties by Aircraft Type & Embarkation Origin

	C130	C130J	C17	C5
Dover	0.0	0.0	0.0	0.0
Travis	22.1	0.0	37.0	0.0
Ramstein	0.0	0.0	0.0	0.0

Stons Supplied	Convoy Equivalent	Airdrop Op Cost
1,900	272	18,729,170.00

Table 16 summarizes the solution for scenarios 3d and 3h in Appendix E by listing the daily sortie rate by both paradrop type to each destination drop zone and aircraft type from each embarkation origin. Also listed is the daily stons supplied, the convoy equivalent representing the number of medium convoys required daily to supply an equivalent weight, and the airdrop operation cost in dollars per day. Although airdrop operation cost per day is less when C-5 aircraft are not available, stons supplied is also less.

The Best Paradrop Type

In this research, where cost per ston and capability in terms of accuracy, minimum deployment altitude, and maximum offset from intended IP, there were no scenario solutions that included conventional (low-altitude) airdrop. Because of the advent of lower cost precision ballistic systems it would be hard to imagine a scenario in which less capability at higher cost would be desirable. However, there may still be a need for low-altitude drops, particularly in tactical situations, where the goal may be to stay low to avoid detection or minimize the airdrop bundles flight time. It should be noted that offset capability of precision guided systems decreases with lower altitudes (Benney 2007).

With HAPAD, both ballistic and guided, cost per ton decreases as the bundle size increases as detailed in Table 17, which was calculated using the cost and payload data discussed previously as listed in Appendix D.

Table 17: Cost per Short Ton by Paradrop Type

	10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
Cost/ston	$4,222	$5,052	$2,444	$36,667	$14,118	$11,320

It is not surprising then that, where other requirements are not restrictive, 10K PBA is the primary paradrop type choice as evidenced by the solutions for Scenario 1 in Tables 5, 6, 7 and 8. Because accuracy and offset capability decline as the paradrop type size increases, the model can be expected to choose larger sizes when requirements allow, but progressively choose smaller, more expensive, paradrop type solutions as accuracy and offset requirements become more demanding as evidenced by the solution for Scenario 2a listed in Table 9 and the solution for Scenario 3a and 3e listed in Table 13.

As pointed out by Dilanian et al. (2006) and Kirsteatter et al. (2006), the cost of an airdrop operation is heavily influenced by the cost per flying hour of the aircraft used as well as the distance flown (as discussed below). However, that should not be read to say that the cost of the airdrop equipment is inconsequential. Although it should not be expected for the operation cost to be reduced by 100 or even 20 times according to the lifespan of the systems as listed in Appendix D, certainly the reduction in cost is still dramatic as evidenced by the solutions listed in Tables 5-16 and summarized below in Table 18.

Table 18: Cost Comparison of One Time Use and Life Span Use Solutions

	1a & 1b	1c & 1d	2a & 2b	2c & 2d	3a/e & 3b/f	3c/g & 3d/h
% Reduction	59%	71%	60%	58%	57%	59%

The Best Aircraft Type

Closely related to the discussion of airdrop cost per ton by paradrop type is the consideration of sortie payload by aircraft type. Aircraft capacity per paradrop type can drastically affect the sortie payload. In Appendix D the sortie payload by paradrop type ranges from 10.84 stons to 12.11 stons for C-130 and C-130J aircraft and from 61.20 stons to 72.68 stons for C-5 aircraft, but for C-17 aircraft, the sortie payload for 30K PGA is only 22.53 stons compared to 32.30 stons to 45.90 stons for other paradrop types. In other words, the cost per ton by paradrop type listed in Table 17 only tells part of the story if it does not also consider aircraft type. In scenarios where C-5 aircraft are not included, 30K PGA is not the least expensive method even if it meets capability requirements as evidenced by comparing solutions for Scenario 1a and 1b in Table 5 and 6 with solutions for Scenario 1c and 1d listed in Table 7 and 8.

Indeed, cost per short ton delivered is influenced by not just the paradrop type, but also the cost per flying hour of the aircraft and the distance flown. Short ton cost per flying hour can be figured by dividing the CPFH and Sortie Payload for each aircraft listed in Appendix D as listed in Table 19.

Table 19: Short Ton Cost Per Flying Hour By AC and Paradrop Type

	10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C-130	$523	$495	$523	$523	$553	$532
C-130J	$618	$586	$618	$618	$655	$630
C-17	$258	$367	$258	$387	$273	$526
C-5	$360	$406	$360	$428	$382	$388

According to the figures in Table 19, C-17 aircraft are the cheapest option for all paradrop types with the exception of the 30K PGA system. It is no surprise then that all scenario solutions exhausted the C-17 sortie supply as displayed in Tables 5-16. However, it is interesting to note C-5 aircraft are cheaper for all paradrop types than C-130 and C-130J aircraft. Furthermore, speed becomes a more significant factor as distance increases. Combining the short ton cost per flying hour by aircraft and paradrop type and the paradrop type cost per short ton (Tables 17 and 19) for a distance 15,000 miles (the approximate longest round trip distance considered in scenarios) is displayed in Figure 3.

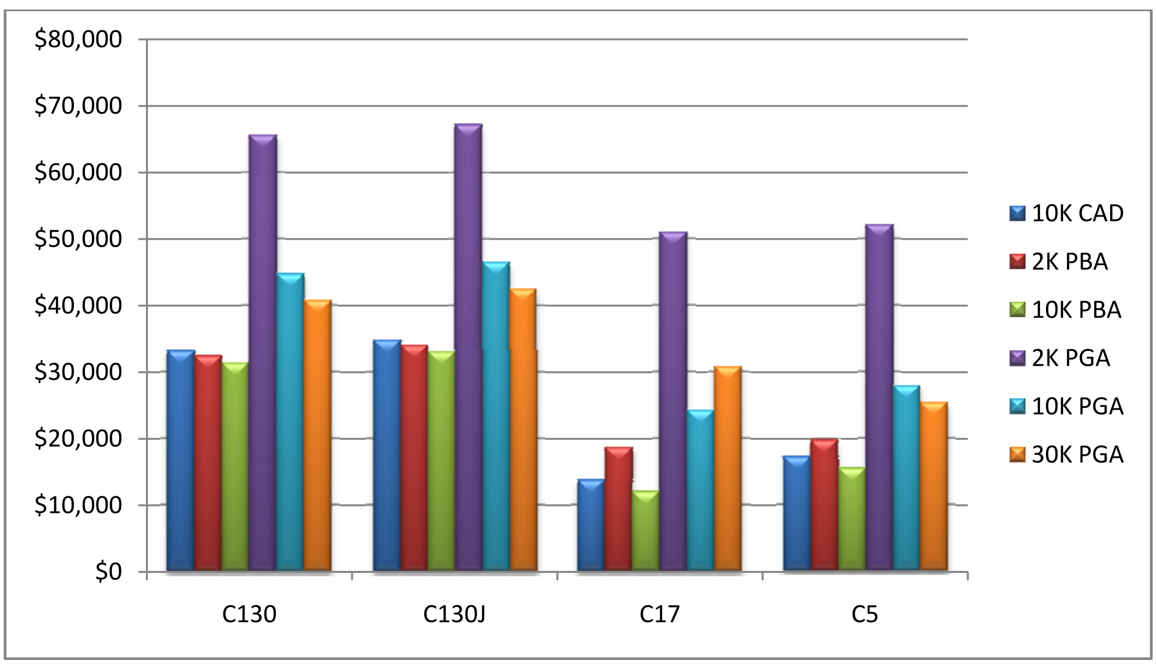

Figure 3. Short Ton Cost by Aircraft and Paradrop Type for 15,000 mile Distance

With the graphical representation of short ton cost by aircraft and paradrop type for a 15,000 mile distance, as displayed in Figure 3, it is obvious the slower speed and lower capacity of C-130 and C-130J aircraft make them uncompetitive in cost with C-17 and C-5 aircraft in a strategic setting. Furthermore, even though C-5 aircraft are only cheaper in cost for the 30K PGA paradrop type, they are competitive with C-17 aircraft in other types as well.

Alternative Method Comparison

In the scenarios described in this research there are no available airfields or seaports; therefore, the only alternative supply method is by convoy. However, it may not be possible to make a meaningful estimation of the cost of transportation by convoy without knowing how far the convoy must travel, and it is not realistic or even feasible to suggest the convoy would travel the distances suggested by the scenarios used for this research. Still there are some meaningful comparisons that can be made in terms of cost. As mentioned previously, one of the advantages of HAPAD is that it keeps aircrew out of harms way; convoys do not have that advantage being particularly vulnerable to small arms fire and IEDs. Dilanian et al. (2006) estimated as much as 5% convoy loss of personnel and vehicles. They suggested an average vehicle replacement cost of $187,778.36 and, without trying to quantify the cost of a causality, they figured the training cost for replacement personnel alone averaged $9,569.00 per soldier (Dilanian et al. 2006). From August 2004 to August 2007 an average of 9.3% of civilian convoys in Iraq were attacked (Michaels 2007). Even if only 5% of those attacks result in damage or casualty the costs are significant as detailed in Table 20, which uses the convoy equivalents discussed at the beginning of this chapter and included with each airdrop solution summary listed in Tables 5-16 and the costs proposed by Dilanian et al. (2006).

Table 20: Replacement Vehicle and Training Cost by Convoy Equivalent

Convoy Equivalent	Personnel 23	Casualties 0.05	Vehicles 10	Damaged 0.05	Training $ $9,569	Vehicle $ $187,778
272	6,256	313	2,720	136	$2,993,183	$25,537,808
415	9,545	477	4,150	208	$4,566,805	$38,963,935
486	11,178	559	4,860	243	$5,348,114	$45,630,054
829	19,067	953	8,290	415	$9,122,606	$77,833,981
1043	23,989	1,199	10,430	522	$11,477,537	$97,926,227
1458	33,534	1,677	14,580	729	$16,044,342	$136,890,162

Even without using current costs for training and vehicle replacement, which have surely risen since 2006, the figures in Table 20 are formidable and worth considering.

As mentioned previously, it is not feasible to consider that the convoy travels the entire distance from the origin to the destination. At some point the convoy must receive its supplies from a sea or air port and each time cargo is transferred or cross-docked from one shipment mode to another there is a potential for loss or damage. Therefore, although it is beyond the scope of this research, for an accurate cost comparison to be made it must include the cost for all legs of the journey as well as loss or damage at trans-shipment facilities. However, at the same time, it would not be feasible to say the airdrop completely eliminates the need for surface or airland transportation. After all, airdrop provides no means for retrograde or reverse logistics. That may not be a big concern for tactical airlift, which supplies primarily consumables, but, when considering strategic airlift, even if the delivery systems are considered expendable, the cargo is most likely not.

Vector

This chapter highlighted the most interesting aspects of the *airdrop model's* output. The next chapter discusses the subsequent recommendations based on those findings.

V. Discussion and Conclusion

Overview

This chapter is divided between recommendations for action and suggestions for further research. The recommendations for action concern the utility and cost of airdrop as wells as the *airdrop model* presented in Chapter III. The suggestions for further research progressively open the sight picture from recommendations related to this research, to HAPAD, and to airdrop in general.

Recommendations

Airdrop Needs to be Rethought

Conventional airdrop accuracy is commonly in terms of first bundle accuracy with the expectation that following bundles will be successively farther from the first. This can be acceptable in a tactical situation where only a few bundles are dropped toward an IP. However, in a strategic setting in which there is a much larger force size with a correspondingly higher sustainment requirement that would require an entire C-17 aircraft load, the separation between bundles becomes problematic as the required drop zone sizes grows. With JPADS first bundle accuracy is the same as for the last; in fact, measures are employed to prevent the bundles from colliding and stacking. Therefore, strategic sustainment using an entire aircraft load of bundles does not require as large a drop zone and becomes much more feasible.

Using airdrop strategically favors different aircraft types. For a conventional, low-altitude, intratheatre tactical drop requiring only a few bundles, C-130 aircraft are well suited. However, for a strategic, intertheatre, HAPAD mission requiring entire aircraft loads of bundles, C-17 and perhaps, as this research concludes, C-5 aircraft are better suited.

Costs Need to be Consistent

Most airdrop system components are designed for at least twenty uses; however, cost is often quoted in terms of acquisition price, which suggests a onetime use. For an accurate comparison between airdrop and alternative methods of resupply to be made, airdrop costs should be spread across the lifespan of the system as this research did. If airdrop systems are intended or expected to be used only once, they should be designed accordingly in order to drive down the acquisition cost.

When comparing the cost of sustainment for an operation using airdrop and the cost using an alternative supply method, the challenge is in capturing all the relevant costs. Because airdrop, as discussed in this research, is a direct shipment method that minimizes or eliminates transshipment, most costs are included in the aircraft operating cost and airdrop equipment costs. However, for a fair and accurate comparison to be made with alternative shipment methods, it is critical that all of the relevant costs for each leg of the shipment be considered. For example, the surface freight cost to ship from origin to a seaport, the cost to ship from origin seaport to destination seaport, and the air freight cost to ship from the destination seaport to final destination as well as any relevant operation, cross docking, and loss or damage costs.

Airdrop Planning Tools Need to be Developed

Airdrop technology and capabilities are evolving more quickly than the planning tools to implement them effectively. With today's arsenal of different aircraft and paradrop types each with their associated strengths and weaknesses, planners need a more robust method for choosing the appropriate mix to employ for each operation that arises. The *airdrop model* presented in this thesis is a foundation for that planning tool. However, there is room for improvement to increase the model's fidelity and accuracy while at the same time increasing the flexibility and ease of use of the tool.

Further Research

The Airdrop Model

To improve the fidelity and accuracy of the model presented in this thesis, further research could examine the sensitivity and formulation of some of the key factors in this *airdrop model*; particularly, those listed as "Planning Data" on the spreadsheets in Appendix E including operations window, aircraft mission capable rate, queuing efficiency, aircraft load factor, and drop loss percentage. Also, it may prove interesting to run more scenarios with different embarkation origins and more destination drop zones with different drop zone requirements to see what other trends emerge.

The spreadsheet used to implement the *airdrop model* was designed with the intention that the only necessary inputs would be embarkation origin fleet size and distance from destination drop zones and destination drop zone altitude, offset, accuracy and weight requirements. However, the spreadsheet was built with fields for only three embarkation origins and four destination drop zones and the binary variables that enforce the constraints regarding offset, altitude, and accuracy must be preprocessed. To make the model more flexible and easier to use, future research could improve the spreadsheet by creating a mechanism to automatically generate the appropriate number of origin and destination fields and to automatically process the binary variables.

JPADS

There are several interesting options to improve the utility of JPADS beyond the scope of this research related to component innovation. Just as this research suggested that the C-5 should be reconsidered if airdrop were regularly employed for strategic operations, an even larger heavy lift airship may further increase the affordability of HAPAD systems as suggested in "Airlift 2025" (Airlift 1996). Even with the present AF aircraft inventory, training costs and paradrop type capabilities could also be improved with the use of aerodynamic pre-rigged airdrop pods as suggested in the AF/A8XC Precision Airdrop Seminar Report (Advanced 2006). Regardless of the type of aircraft and bundle used, the utility of JPADS may also be improved (particularly for tactical applications) by the advent of in-flight load select system that function similarly to the rotary launch assembly (RLA) on a bomber as discussed in Garretson (2005). Research suggesting the appropriate design of any of these systems could be incorporated with the airdrop model presented in this research to estimate the effect on airdrop capacity and cost.

Airdrop

Although this research focused on the cost of airdrop in a strategic setting, it may be just as interesting to focus on the timeliness of delivery in a tactical setting were cost is not the primary concern. In that regard, perhaps the airdrop model could be adjusted to optimize for time of delivery comparing a convoy to airdrop. Furthermore, the research may suggest what types of loads should be preconfigured and scenario variations could model the time savings for a preconfigured load with an "alert" status crew.

Regardless of the type of airdrop and aircraft used and whether the setting is strategic or tactical, any airdrop operation is dependent on recovering the airdrop equipment. Research suggesting an effective retrograde policy and procedures, as well as a means to enforce the policy, is desperately needed to support the viability of airdrop and the validity of any research related to it.

Conclusion

There is clearly a need for safe, reliable resupply where runways, roads, and waterways are not available, particularly when not relying on foreign support. There are some places that aircraft, trucks and boats simply can not reach due to terrain, others they can't even get close to due to politics, and many that can be approach without coming under hostile fire. With the aircraft and paradrop systems in today's arsenal airdrop has unprecedented capacity and capability; planners need only be given the tools and support to exploit it. With development and indoctrination of the *airdrop model* presented in this research they will have it.

Appendix A: Glossary of Acronyms and Abbreviations

AAA	Anti-aircraft Artillery
AGAS	Affordable Guided Airdrop System
AGL	Above Ground Level
AGU	Airborne Guidance Unit
AMP	Avionics Modernization Program
AMWC	Air Mobility Warfare Center
BRAC	Base Realignment and Closure
BSP	Baseline Security Posture
CAD	Conventional Airdrop
CARP	Computed Air Release Point
CDS	Container Delivery System
CPFH	Cost Per Flying Hour
CROP	Containerized Roll-in/out Platform
CTS	Combat Training Squadron
CT	Cycle Time
DPA	Defense Planning Scenario
E-CDS	Enhanced CDS
GPADS	Guided Parafoil Airdrop Delivery System
GPS	Global Positioning System
GRADS	Ground Radar System
GWOT	Global War On Terrorism
HAPAD	High-Altitude Precision Airdrop

HEMTT	Heavy Expanded Mobility Tactical Truck
HQ AF	Headquarters Air Force
I-CDS	Improved Container Delivery System
IED	Improvised Explosive Device
IP	Impact Point
JPADS	Joint Precision Airdrop System
JPADS-MP	JPADS Mission Planner
LAR	Launch Acceptance Region
MANPADS	Man Portable Air Defense Systems
MHE	Material Handling Equipment
MC	Mission Capable
MMIST	Mist Mobility Integrated Systems Technology
MRE	Meal Read- to-Eat
MSFD	Multi-Service Force Data
OPLOG	Operational Logistics
PATCAD	Precision Airdrop Technology Conference and Demonstration
PBA	Precision Ballistic Airdrop
RERP	Reliability Enhancement and Re-engining Program
PGA	Precision Guided Airdrop
RPGs	Rocket-Propelled Grenades
RTFT	Round Trip Flying Time
RTGT	Round Trip Ground Time
SAMs	Surface-to-Air Missiles

SOPAD	Standoff Precision Airdrop
Stons	Short Tons
TPFDD	Time-Phased Forced Deployment data
WGRS	Wireless Gate Release System

Appendix B: Supplemental History

Origin

It is interesting that the parachute greatly predates manned flight. When many people consider the origin of the parachute they probably envision the pyramidal drawing of Leonardo da Vinci from the late 1400s. However, the Chinese are commonly given credit for the invention of the umbrella and, in fact, the French monk Vasson's translation of the Beijing archives indicate that Chinese acrobats used an umbrella-like device as a parachute as early as the 12^{th} century (Mink 1944). However, the word parachute is of French origin as that is where most early development was accomplished. Several different Frenchmen dropped different animals and even people from various towers refining their designs. Like da Vinci's plan, most had a rigid frame limiting their versatility. The practical use for the parachute was envisioned as a means for escaping burning buildings (Mink 1944); however, parachutes were more often employed by stuntmen…like the Chinese. Before the dawn of aviation, parachutes had evolved beyond rigid frames but in the early days of air travel, both by balloon and airplane, parachutes were not commonly employed as they were too bulky, too expensive, and simply not reliable (Mink 1944).

World War I

As with many major technological developments, war proved to advance the science of airdrop. By 1914, World War I refocused the value of parachutes as life saving devices. As many as 1,000 balloonists were saved during the war, but parachutes were not universally used in planes until 1918 (Mink 1944). Also, finally by 1918, the British Royal Air Force accomplished the first successful aerial supply mission dropping

1,220 sandbags and 60 boxes of ammunition to Allied Belgian and French troops in the Houthulst Forest using 200 sorties between the first and fourth of October (Wragg 1986).

World War II

The next major developments in airdrop likewise occurred in preparation for or during World War II. During this time frame the Russians accomplished the most pioneering work in airborne assault. By 1940, one million Russian troops were trained to jump out of *functional* aircraft not only for combat but also to supply remote communities with food, mail and medicine as well as to fight forest fires (Mink 1944). Germany was close behind with its paratroop program establishing a training school in Spandau in 1936 and using those troops for the invasion of Poland and then Holland in 1939 and 1940 but, most impressively, with the drop of twenty-five to thirty thousand troops in Crete (Mink 1944). Meanwhile, from late 1935 to early 1936 the Italian Regia Aeronautica delivered 2,000 tons of supplies (mostly food and ammunition) by airlift and airdrop (with and without chutes) to troops in Ethiopia (Wragg 1986). However, the aircraft used by the Italians were bomber-transports rather than true cargo planes as planners still were reluctant to dedicate resources strictly to transport (Wragg 1986). By the end of the war, however, the value of dedicated transports was evident. The challenge for future conflicts became how to best employ this new capability.

The Berlin Airlift

Immediately following World War II events transpired in Germany that would test the limit of airlift. The country was divided into four zones controlled by the Americans, British, French and Russians as illustrated in Figure 4. Although the city of Berlin was completely inside the Russian zone, it was also divided into four sectors. On

June 22, 1948, two years after Winston Churchill's famous speech at Westminster College in Fulton, Missouri, in which he described the growing animosity with the Russians as an "Iron Curtain", the Russians completely blocked all surface transportation to western controlled sectors of Berlin (Miller 1998). General Lucius Clay, the U.S. military governor in Germany, wanted to send an escorted convoy through the blockade but President Truman prompted General Clay to work with Major General Curtis Lemay, Commander of the U.S. Air Force in Europe, to pursue airlift as British Foreign Minister Ernest Brevin suggested (U.S. 2007).

Figure 4. Occupation Zones and Air Corridors in Germany 1945-49 (U.S. 2007)

There were three air corridors protected by treaty that were used between the western zones and Berlin. Likewise, there were three major airfields in Berlin. U.S. operations were primarily from Rhein-Main in the American zone of Germany to Templehof in the American sector of Berlin, a distance of 170 miles (Miller 1998). At the outset of the airlift the United States had 98 Douglas C-47 Skytrain aircraft in Europe with a cargo capacity of three tons each. Within the first two weeks 300 Douglas C-54 Skymaster aircraft with a cargo capacity of 10 tons each arrived from Alabama, Hawaii, Texas and the Panama Canal (U.S. 2007). Although ground traffic was delivering 13,500 tons of cargo per day before the blockade, estimates were that the airlift would need to last three weeks and provide at least 2,000 tons of cargo per day for basic subsistence (Miller 1998).

Strict rules were developed to ensure maximum cargo delivery. Planes took off every three minutes flying at staggered altitudes to fill the air corridor to capacity. Pilots were always required to use instrument flight rules regardless of visibility, they were only given one chance to land at Berlin otherwise they would have to return to Rhein-Main full, and they were not allowed to leave their plane for any reason while in Berlin (U.S. 2007). During the course of the airlift, which lasted 321 days, over 2.3 million tons of cargo was delivered, almost 1.8 million tons by the Americans alone, and the most delivered in 24 hours was 12,940 tons (Miller 1998).

Concerning this research, the two most important impacts of the Berlin airlift as Miller (1998) identified are that it displayed the capability of airlift in a demonstration that has not been surpassed since and it validated the need for larger military-specific global transports rather than the civilian adaptations that were being used.

Appendix C: Supplemental JPADS Information

JPADS Design

The success of JPADS is directly related to its innovative design. From the ground up JPADS consists of: the cargo platform, the AGU and the decelerators, as well as a dropsonde and the mission planning hardware and software (McGowan, 2006).The cargo platform depends on the payload. Smaller payloads, fewer than 2,000 pounds, use an I-CDS, which denotes a traditional CDS coupled with the mission planning software (Diaz 2007). The CDS uses an A-series container measuring at maximum 30 inches wide by 66 inches high and 48 inches deep as pictured in Figure 5 (Container 2007). The container generally sits on a honeycomb cardboard sheet to absorb impact and a 3/4-inch plywood skid board (Container 2007). Even without the rest of the JPADS package this improvement alone yields about a 60 percent increase in airdrop accuracy (Diaz 2007). Larger payloads up to 10,000 pounds use an Enhanced CDS pallet. Although similar in appearance to the more common 463L pallet both with aluminum construction, measuring 108 inches by 88 inches, and compatible with both C-130 and C-17 locks and rails, the E-CDS pallet is 575 pounds and has the addition of on-deck tie downs and suspension D-rings (JPADS 2006). A new plastic composite E-CDS pallet is also being developed. For loads up to 30,000 pounds, three eight-foot sections of the aluminum Type V airdrop platform are used (ATI 2007).

Figure 5. I-CDS with JPADS (Benney 2005)

The distinction between I-CDS and JPADS is dependent on the AGU and the decelerators, which include both the parafoil and the parachute. In Figure 5 the AGU is the box above the I-CDS with the decelerators lying on top of it. The AGU houses a rechargeable battery, the GPS receiver, and the steering actuators, which are connected by lines to the parafoil. The parafoil is rectangular and steerable whereas the parachute is circular and relatively unwieldy. Although I-CDS, E-CDS and JPADS all use the Mission Planner, the AGU and decelerators are what allow JPADS to make corrections to its drop after it has left the aircraft. In other words, the AGU makes the difference between a precision ballistic and a precision guided airdrop.

The JPADS Mission Planning hardware components are a 12-inch 3-pound wind sonde sensor or dropsonde, a high-pressure tolerant laptop computer, and a portable interface processor as pictured in Figure 6 (Diaz 2007; Joint 2007). Mission planning may also use the aircraft's power, antennae, 1553 data bus and secure data communications if available (Joint 2007).

Figure 6. Panasonic Toughbook, Dropsonde (with chute), Interface Processor and Connections (Benney 2005)

Also worthy of mention, though not specifically related to JPADS, is the development of the Wireless Gate Release System (WGRS). This system first demonstrated in February 2007 allows for the loadmaster to remotely deploy cargo rather than manually releasing as is presently required. Obviously, this is much safer for the loadmaster but there are two other important benefits. The WGRS allows for individual cargo bundles to be released separately, which helps prevent loads from colliding after release and facilitates the incorporation of multiple IPs, and also allows for more cargo bundles to be loaded as there is not a need to leave room for the loadmaster to release them (Coy 2007).

JPADS Operation

An airdrop of JPADS is similar to a typical airdrop but there are important differences in every stage beginning with cargo preparation and continuing through mission planning and, of course, the actual cargo drop.

As listed above, JPADS, I-CDS, and E-CDS have unique cargo configurations requiring specialized cargo build-up training. The "train the trainer" courses are being taught by the 34th Combat Training Squadron (CTS) at Little Rock Air Force Base, Arkansas. The first group of ten active duty, Air National Guard and Air Force Reserve units from across the C-130 and C-17 communities gathered there for the first course in November 2006 (George, K. 2006). Lt. Col Jeff Szczepanik, the 34th CTS commander, said the crews leave fully qualified on JPADS and I-CDS after two phases of ground training and operational training then take the training back to their units to train others (George, K. 2006). Given that the 34th CTS was only given three weeks to prepare the course, the urgency and need for this capability in the field is apparent.

Although traditional airdrops from C-130 Hercules and C-17 Globemaster aircraft are from altitudes of 400 to 1,000 feet, JPADS is designed to put a load from as high as 25,000 feet into a drop zone the size of a soccer field (Sturkol 2007; McGowan 2006). That kind of accuracy is dependent on the Mission Planner. Once the aircraft is near the target at the correct altitude, the dropsonde is deployed to measure wind speed, which is relayed back to the Mission Planner (Diaz 2007). For particularly valuable drops, multiple dropsondes may be deployed for redundancy. However, to minimize time over target, the dropsondes may often be deployed several miles before the actual intended IP. Furthermore, with confidence in the currency and accuracy of forecasted winds, the dropsonde may not be used at all. The Mission Planner combines the information received from the dropsonde or forecasts with the aircrafts altitude and speed, the cargo's weight, and desired impact points (Daniel 2005). If any information changes, the JPADS-MP can send the updates wirelessly to the AGUs (Cupp 2005). JPADS-MP also uses this information to find the optimum Computed Air Release Point (CARP) and the LAR (Joint 2007). Together the CARP and LAR define the "cone of opportunity" from within which the AGU can correct to put the load on target (Cupp 2005). However, taking the idea one step further, the area where multiple cones overlap defines a space from which all loads can be deployed to land at multiple drop zones as picture in Figure 7. Once the updates have been made and the aircraft has reached the release point, for gravity extracted systems the pilot will raise the nose about 7 degrees, the cargo will roll out the back; otherwise, the extraction chute will be deployed pulling the cargo out. In either case, once the cargo leaves the aircraft the AGU takes control (Diaz 2007).

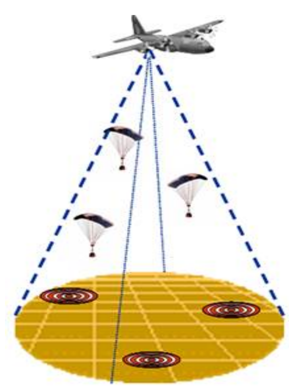

Figure 7. JPADS enables multiple IPs from a single release point (Sturkol 2007)

The AGU uses its GPS receiver to judge its position then autonomously makes necessary adjustments using the parafoil's risers (attached to the AGU's actuators) to fly the cargo to the specified drop zone (Kurle 2006). For the Strong Enterprises Screamer system, of which about 50 are currently in use, at about 500 feet above ground level the parachute deploys, slowing the descent to a safe speed and dropping the cargo almost straight down (Kurle 2006). The systems identified for the program of record use a larger parafoil eliminating the need for the recovery chute.

That is how JPADS accomplishes precision airdrop from high altitude. As Major General David Gray, Air Mobility Warfare Center (AMWC) Commander, stated, “This is a revolution in the way air mobility supports the war fighter” (Sturkol 2007). But as Major Dan Devoe, AMWC JPADS project officer, also said, “this technology and its applications are only at the beginning, the sky is the limit on where this can go for improving operations in the battlefield” (Sturkol 2007).

JPADS Applications (sizes)

JPADS is commonly described as a family of systems with four distinct categories defined by payload capacity with multiple manufactures for systems in each category.

The Extra Light category, or JPADS XL, is for cargo up to 2,200 pounds. This was the first category to be aggressively researched. Typical application for this category includes food, water and ammunition resupply for small tactical units using the I-CDS. Mist Mobility Integrated Systems Technology’s (MMIST) Sherpa, Capewell’s Affordable Guided Airdrop System (AGAS), and Strong Enterprises’ Screamer systems all fit in this category (Benney 2005).

The Light category is for cargo from 2,200 to 10,000 pounds. As discussed above, this category uses the enhanced CDS pallet, which is similar in size, appearance, and capacity to the common 463L pallet. As such, almost anything that can go on a 463L should be deliverable with JPADS Light. Strong Enterprises also makes a 10,000-pound capacity Screamer. The program of record is the Deployable Ram-Air Glider with Optimum Navigation FLYing (DRAGONFLY) system from a joint contractor team called Airborne Systems; Para-Flight provides the chute, Wamore Inc. provides the AGU, Robotek Engineering provides the avionics and Draper Laboratories provides the software (Benney 2005).

The Medium category is for cargo from 10,000 to about 30,000 pounds. That capacity allows for airdrop of some vehicles or perhaps the Heavy Expanded Mobility Tactical Truck's (HEMTT) containerized roll-in/out platform (CROP), which is an A-frame type flat rack that fits inside a 20-foot International Standards Organization container (Heavy 2007). Airborne Systems tackled this weight class with the MegaFly as demonstrated at the Biennial Precision Airdrop Technology Conference and Demonstration (PATCAD) at the Yuma AZ proving ground in October 2007.

The Heavy category is for cargo up to 60,000 pounds. This category is still highly conceptual but this capacity would allow for heavy equipment including the Army's 19-ton armored Stryker vehicle (Kissell 2007).

These categories certainly don't limit the capacity of JPADS. JPADS is also being applied to personnel to enable limited visibility paratroop drops. The U.S. Marines in particular have expressed particular in interest in an ultra-light class for cargo under 1,000 pounds (Coy 2007). Also companies like STARA Technologies have envisioned and demonstrated what may be called a nano-light category for cargo from 1 to 400 pounds used to drop things like sensors and communications relays (STARA 2007). As the technology matures it is likely that it will support other specialized applications.

Appendix D: Aircraft and Paradrop Type Data

Aircraft Type Data								
	Air Force	CPFH	Speed	RTGT	Max ACL	Positions		
AC	Inventory	($)	(mph)	(hrs)	(lbs)	2K	10K	30K
C130	450	5,991	271	4.5	42,000	16	5	1
C130J	35	7,096	303	4.5	44,000	24	7	1
C17	155	11,851	405	6.5	170,900	40	12	3
C5	109	26,199	415	8.5	270,000	80	24	6

In the Aircraft Type Data Table "Air Force Inventory" lists the number of units of each aircraft type in the Air Force according to *Airman Magazine* (Heritage 2007). "CPFH" lists the cost per flying hour in dollars for C-130H, C-130J, C-17A and C-5B as posted by the Office of the Under Secretary of Defense (Reimbursable 2008). Air Mobility Planning Factors lists aircraft speeds as "block speeds" based on distance flown (AFPAM 10-1403 2003). The value listed for each aircraft type "speed" is the lowest block speed in miles per hour in the range of 2,000 to 6,000 miles for each aircraft type. Because C-130J figures are not listed, its speed is interpolated by multiplying C-130 block speed by the ratio of C-130 maximum speed and C-130J maximum speed as listed in *Airman Magazine* (Heritage 2007). "RTGT" lists the sum of "onload" and "offload" ground times in hours as listed in "Air Mobility Planning Factors" (AFPAM 10-1403 2003). "Max ACL" lists the maximum allowable cabin load in pounds using the figures listed as "maximum load", "load", or "maximum cargo" on the U.S. Air Force factsheets (Factsheets 2007). "Positions" lists the aircraft load capacity for each paradrop type as the number of bundles of each paradrop type size that each aircraft type can carry considering both the weight and volume capacities of the aircraft. Basically, the rigged weight of each paradrop type bundle (as opposed to the payload weight) was divided into the cargo weight allowance of the aircraft type and rounded down. Similarly, for volume, the floor space in the cargo cabin of each aircraft type was compared against the footprint of each paradrop type bundle. The aircraft type capacity of each paradrop type size is the lower of either the weight or volume capacity. The AMC Airlift/Airdrop Branch provided values for C-130, C-130J, and C-17 aircraft using the aircrafts maximum allowable cabin load ACL as the weight limit (Fields 2007).

Paradrop Type Data								
Drop Type	Rigged Weight	Payload	System Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10,000	8,800	$19,000	100	$190	3,000	0	200
2K PBA	2,300	2,200	$4,800	60	$80	15,000	0	400
10K PBA	10,000	9,200	$11,000	60	$183	24,500	0	400
2K PGA	2,400	2,200	$33,000	20	$1,650	24,500	20	150
10K PGA	10,000	8,500	$60,000	20	$3,000	24,500	20	250
30K PGA	30,000	26,500	$150,000	20	$7,500	24,500	8	300

In the Paradrop Type Data table "Rigged Weight" lists the weight in pound of each complete paradrop type bundle as opposed to the "payload" which lists the weight of the bundle without rigging equipment such as decelerators, platforms and guidance units if used. "Systems Cost" lists the cost in dollars for one complete bundle of each paradrop type not including any components that stay on the aircraft after deployment such as the JPADS-MP. "Lifespan" lists the design life of each paradrop type in number of uses. "Use Cost" lists the cost per use in dollars by dividing "System Cost" by "Life Span". "Altitude" lists the maximum deployment altitude in feet for each paradrop type. "Offset" lists the maximum distance in miles from the intended IP that each paradrop type can be deployed. "Accuracy" lists the maximum distance in meters from the intended IP that all bundles of each paradrop type will land within. All paradrop type data was provided by Mr. Scott Martin and Mr. Richard Benney from the USA Natick Soldier Center (Benney 2007, Martin 2008).

Appendix E: Airdrop Model Solutions

Scenario 1a Solution

Aircraft Characteristics

AC	Max Load	Speed	CPFH	RTGT	RTFT Origin A	RTFT Origin B	RTFT Origin C	CT Origin A	CT Origin B	CT Origin C
C130	42,000	271	$5,991	4.5	45.3	54.9	16.2	49.8	59.4	20.7
C130J	44,000	303	$7,096	4.5	40.5	49.1	14.5	45.0	53.6	19.0
C17	170,900	405	$11,851	6.5	30.3	36.7	10.8	36.8	43.2	17.3
C5	270,000	415	$26,199	8.5	29.6	35.9	10.6	38.1	44.4	19.1

Sortie Characteristics

AC	Plan Load	System Load 2K	System Load 10K	System Load 30K	Sortie Payload 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics

Origin	Distance	Fleet Available C130	C130J	C17	C5	Sorties Available C130	C130J	C17	C5
A	6,140	0	0	0	0	0.0	0.0	0.0	0.0
B	7,440	0	0	0	0	0.0	0.0	0.0	0.0
C	2,190	65	0	40	15	64.2	0.0	47.1	16.1

Drop Type Characteristics

Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	100	$190	3,000	0	2200
2K PBA	2K	0.95	$4,800	60	$80	15,000	0	1000
10K PBA	10K	4.50	$11,000	60	$183	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics

AC	Flight Cost ($) Origin A	Origin B	Origin C	Rigging Cost ($) 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	271,474	328,952	96,829	57,000	72,000	33,000	495,000	180,000	150,000
C130J	287,587	348,477	102,576	57,000	72,000	33,000	495,000	180,000	150,000
C17	359,334	435,415	128,166	228,000	192,000	132,000	1,320,000	720,000	300,000
C5	775,238	939,376	276,510	361,000	384,000	209,000	2,640,000	1,140,000	900,000

Drop Zone Requirements

DZ	Stons	Altitude	Offset	Accuracy
D1	850	800	0	2500
D2	850	800	0	2500
D3	850	8000	0	2500
D4	850	800	0	500

	Max Stons C130	C130J	C17	C5
A	0.00	0.00	0.00	0.00
B	0.00	0.00	0.00	0.00
C	777.32	0.00	2,163.14	1,167.12
			Total	4,107.58

Solution

Origin	Sorties Flown C130	C130J	C17	C5	Stons Supplied D1	D2	D3	D4	Total Cost
A	0.0	0.0	0.0	0.0	850	850	850	849.9569	$30,204,196
B	0.0	0.0	0.0	0.0					
C	11.1	0.0	47.1	16.1					

SOPAD Requirements (Altitude, Offset, Accuracy)

D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D2	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D3	Altitude	8000	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	0.00	0.00
10K PBA	18.52	18.52	15.41	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	0.00	0.00	0.00
30K PGA	0.00	0.00	0.00	21.79

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties Required			Sortie	Sortie		Stons Delivered		
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$0		0	0	0	0
TOTALS						Sum Cost		D1	D2	D3	D4

Origin C	Ramstein AB										
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	11.05	11.05	2,727,457	0	0	0	124
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	18.52	18.52	10.09	0.00	47.13	12,260,931	850	850	463	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	5.32	0.00	5.32	2,584,431	0	0	387	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	10.74	10.74	12,631,377	0	0	0	726
						$30,204,196		850	850	850	850
TOTAL						Sum	Cost	D1	D2	D3	D4

Scenario 1b Solution

Aircraft Characteristics

	Max					RTFT			CT	
AC	Load	Speed	CPFH	RTGT	Origin A	Origin B	Origin C	Origin A	Origin B	Origin C
C130	42,000	271	$5,991	4.5	45.3	54.9	16.2	49.8	59.4	20.7
C130J	44,000	303	$7,096	4.5	40.5	49.1	14.5	45.0	53.6	19.0
C17	170,900	405	$11,851	6.5	30.3	36.7	10.8	36.8	43.2	17.3
C5	270,000	415	$26,199	8.5	29.6	35.9	10.6	38.1	44.4	19.1

Sortie Characteristics

	Plan		System Load				Sortie	Payload		
AC	Load	2K	10K	30K	10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics

			Fleet	Available			Sorties	Available	
Origin	Distance	C130	C130J	C17	C5	C130	C130J	C17	C5
A	6,140	0	0	0	0	0.0	0.0	0.0	0.0
B	7,440	0	0	0	0	0.0	0.0	0.0	0.0
C	2,190	65	0	40	15	64.2	0.0	47.1	16.1

Drop Type Characteristics

Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	20	$950	3,000	0	2200
2K PBA	2K	0.95	$4,800	20	$240	15,000	0	1000
10K PBA	10K	4.50	$11,000	20	$550	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics

	Flight Cost ($)					Rigging	Cost ($)		
AC	Origin A	Origin B	Origin C	10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	271,474	328,952	96,829	2,850	3,600	1,650	24,750	9,000	7,500
C130J	287,587	348,477	102,576	2,850	3,600	1,650	24,750	9,000	7,500
C17	359,334	435,415	128,166	11,400	9,600	6,600	66,000	36,000	15,000
C5	775,238	939,376	276,510	18,050	19,200	10,450	132,000	57,000	45,000

Drop Zone Requirements

DZ	Stons	Altitude	Offset	Accuracy
D1	850	800	0	2500
D2	850	800	0	2500
D3	850	8000	0	2500
D4	850	800	0	500

		Max	Stons	
	C130	C130J	C17	C5
A	0.00	0.00	0.00	0.00
B	0.00	0.00	0.00	0.00
C	777.32	0.00	2,163.14	1,167.12
			Total	4,107.58

Solution

		Sorties	Flown			Stons	Supplied		Total Cost
Origin	C130	C130J	C17	C5	D1	D2	D3	D4	
A	0.0	0.0	0.0	0.0	850	850	850.054	850	$12,529,297
B	0.0	0.0	0.0	0.0					
C	9.9	0.0	47.1	16.1					

SOPAD Requirements (Altitude, Offset, Accuracy)							
	D1	Altitude	800	Offset	0	Accuracy	2500
		≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
	10K CAD	3,000	1	0	1	2200	1
	2K PBA	15,000	1	0	1	1000	1
	10K PBA	24,500	1	0	1	2200	1
	2K PGA	24,500	1	20	1	150	1
	10K PGA	24,500	1	8	1	250	1
	30K PGA	24,500	1	8	1	300	1
	D2	Altitude	800	Offset	0	Accuracy	2500
		≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
	10K CAD	3,000	1	0	1	2200	1
	2K PBA	15,000	1	0	1	1000	1
	10K PBA	24,500	1	0	1	2200	1
	2K PGA	24,500	1	20	1	150	1
	10K PGA	24,500	1	8	1	250	1
	30K PGA	24,500	1	8	1	300	1
	D3	Altitude	8000	Offset	0	Accuracy	2500
		≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
	10K CAD	3,000	0	0	1	200	1
	2K PBA	15,000	1	0	1	1000	1
	10K PBA	24,500	1	0	1	2200	1
	2K PGA	24,500	1	20	1	150	1
	10K PGA	24,500	1	8	1	250	1
	30K PGA	24,500	1	8	1	300	1
	D4	Altitude	800	Offset	0	Accuracy	500
		≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
	10K CAD	3,000	1	0	1	2200	0
	2K PBA	15,000	1	0	1	1000	0
	10K PBA	24,500	1	0	1	2200	0
	2K PGA	24,500	1	20	1	150	1
	10K PGA	24,500	1	8	1	250	1
	30K PGA	24,500	1	8	1	300	1

Sorties by DropType				
	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	9.89	0.00
10K PBA	16.37	18.52	15.91	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	0.00	0.00	12.38
30K PGA	0.00	0.00	0.00	0.00

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties Required			Sortie	Sortie		Stons Delivered		
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$0		0	0	0	0
TOTALS						Sum Cost		D1	D2	D3	D4

Origin C	Ramstein AB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	9.89	0.00	9.89	993,240	0	0	120	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	12.70	18.52	15.91	0.00	47.13	6,351,171	583	850	730	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	3.68	0.00	0.00	0.00	3.68	1,054,732	267	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	12.38	12.38	4,130,154	0	0	0	850
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$12,529,297		850	850	850	850
TOTAL						Sum	Cost	D1	D2	D3	D4

Scenario 1c Solution

Aircraft Characteristics

AC	Max Load	Speed	CPFH	RTGT	RTFT Origin A	RTFT Origin B	RTFT Origin C	CT Origin A	CT Origin B	CT Origin C
C130	42,000	271	$5,991	4.5	45.3	54.9	16.2	49.8	59.4	20.7
C130J	44,000	303	$7,096	4.5	40.5	49.1	14.5	45.0	53.6	19.0
C17	170,900	405	$11,851	6.5	30.3	36.7	10.8	36.8	43.2	17.3
C5	270,000	415	$26,199	8.5	29.6	35.9	10.6	38.1	44.4	19.1

Sortie Characteristics

AC	Plan Load	System Load 2K	System Load 10K	System Load 30K	Sortie Payload 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics

Origin	Distance	Fleet Available C130	C130J	C17	C5	Sorties Available C130	C130J	C17	C5
A	6,140	0	0	0	0	0.0	0.0	0.0	0.0
B	7,440	0	0	0	0	0.0	0.0	0.0	0.0
C	2,190	65	0	40	0	64.2	0.0	47.1	0.0

Drop Type Characteristics

Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	100	$190	3,000	0	2200
2K PBA	2K	0.95	$4,800	60	$80	15,000	0	1000
10K PBA	10K	4.50	$11,000	60	$183	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics

AC	Flight Cost ($) Origin A	Origin B	Origin C	Rigging Cost ($) 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	271,474	328,952	96,829	57,000	72,000	33,000	495,000	180,000	150,000
C130J	287,587	348,477	102,576	57,000	72,000	33,000	495,000	180,000	150,000
C17	359,334	435,415	128,166	228,000	192,000	132,000	1,320,000	720,000	300,000
C5	775,238	939,376	276,510	361,000	384,000	209,000	2,640,000	1,140,000	900,000

Drop Zone Requirements

DZ	Stons	Altitude	Offset	Accuracy
D1	725	800	0	2500
D2	725	800	0	2500
D3	725	8000	0	2500
D4	725	800	0	500

	Max Stons C130	C130J	C17	C5
A	0.00	0.00	0.00	0.00
B	0.00	0.00	0.00	0.00
C	777.32	0.00	2,163.14	0.00
			Total	2,940.46

Solution

Origin	Sorties Flown C130	C130J	C17	C5	Stons Supplied D1	D2	D3	D4	Total Cost
A	0.0	0.0	0.0	0.0	725	725	725	725	$48,540,569
B	0.0	0.0	0.0	0.0					
C	64.2	0.0	47.1	0.0					

SOPAD Requirements (Altitude, Offset, Accuracy)

D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D2	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D3	Altitude	8000	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	5.78	0.00	0.00	0.00
10K PBA	14.27	15.80	15.80	0.00
2K PGA	0.00	0.00	0.00	58.39
10K PGA	0.00	0.00	0.00	1.27
30K PGA	0.00	0.00	0.00	0.00

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTALS						Sum	Cost	D1	D2	D3	D4

Origin C	Ramstein AB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	5.78	0.00	0.00	0.00	5.78	976,323	70	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	58.39	58.39	34,557,906	0	0	0	670
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	14.27	15.80	15.80	0.00	45.86	11,931,118	655	725	725	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	1.27	1.27	1,075,221	0	0	0	55
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$48,540,569		725	725	725	725
TOTAL						Sum Cost		D1	D2	D3	D4

Scenario 1d Solution

Aircraft Characteristics										
	Max					RTFT			CT	
AC	Load	Speed	CPFH	RTGT	Origin A	Origin B	Origin C	Origin A	Origin B	Origin C
C130	42,000	271	$5,991	4.5	45.3	54.9	16.2	49.8	59.4	20.7
C130J	44,000	303	$7,096	4.5	40.5	49.1	14.5	45.0	53.6	19.0
C17	170,900	405	$11,851	6.5	30.3	36.7	10.8	36.8	43.2	17.3
C5	270,000	415	$26,199	8.5	29.6	35.9	10.6	38.1	44.4	19.1

Sortie Characteristics										
	Plan	System Load					Sortie	Payload		
AC	Load	2K	10K	30K	10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics									
			Fleet	Available			Sorties	Available	
Origin	Distance	C130	C130J	C17	C5	C130	C130J	C17	C5
A	6,140	0	0	0	0	0.0	0.0	0.0	0.0
B	7,440	0	0	0	0	0.0	0.0	0.0	0.0
C	2,190	65	0	40	0	64.2	0.0	47.1	0.0

Drop Type Characteristics								
Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	20	$950	3,000	0	2200
2K PBA	2K	0.95	$4,800	20	$240	15,000	0	1000
10K PBA	10K	4.50	$11,000	20	$550	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics									
	Flight Cost ($)					Rigging	Cost ($)		
AC	Origin A	Origin B	Origin C	10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	271,474	328,952	96,829	2,850	3,600	1,650	24,750	9,000	7,500
C130J	287,587	348,477	102,576	2,850	3,600	1,650	24,750	9,000	7,500
C17	359,334	435,415	128,166	11,400	9,600	6,600	66,000	36,000	15,000
C5	775,238	939,376	276,510	18,050	19,200	10,450	132,000	57,000	45,000

Drop Zone Requirements				
DZ	Stons	Altitude	Offset	Accuracy
D1	725	800	0	2500
D2	725	800	0	2500
D3	725	8000	0	2500
D4	725	800	0	500

		Max	Stons	
	C130	C130J	C17	C5
A	0.00	0.00	0.00	0.00
B	0.00	0.00	0.00	0.00
C	777.32	0.00	2,163.14	0.00
			Total	2,940.46

	Solution								
		Sorties	Flown			Stons	Supplied		Total Cost
Origin	C130	C130J	C17	C5	D1	D2	D3	D4	
A	0.0	0.0	0.0	0.0	725	725	725	725	$14,068,405
B	0.0	0.0	0.0	0.0					
C	64.2	0.0	47.1	0.0					

SOPAD Requirements (Altitude, Offset, Accuracy)

D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D2	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D3	Altitude	8000	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	5.78	0.00	0.00	0.00
10K PBA	14.27	15.80	15.80	0.00
2K PGA	0.00	0.00	0.00	58.39
10K PGA	0.00	0.00	0.00	1.27
30K PGA	0.00	0.00	0.00	0.00

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTALS						Sum	Cost	D1	D2	D3	D4

Origin C	Ramstein AB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	5.78	0.00	0.00	0.00	5.78	580,771	70	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	58.39	58.39	7,099,192	0	0	0	670
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	14.27	15.80	15.80	0.00	45.86	6,180,328	655	725	725	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	1.27	1.27	208,114	0	0	0	55
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$14,068,405		725	725	725	725
TOTAL						Sum	Cost	D1	D2	D3	D4

Scenario 2a Solution

Aircraft Characteristics										
	Max					RTFT			CT	
AC	Load	Speed	CPFH	RTGT	Origin A	Origin B	Origin C	Origin A	Origin B	Origin C
C130	42,000	271	$5,991	4.5	45.3	54.9	16.2	49.8	59.4	20.7
C130J	44,000	303	$7,096	4.5	40.5	49.1	14.5	45.0	53.6	19.0
C17	170,900	405	$11,851	6.5	30.3	36.7	10.8	36.8	43.2	17.3
C5	270,000	415	$26,199	8.5	29.6	35.9	10.6	38.1	44.4	19.1

Sortie Characteristics										
	Plan	System Load					Sortie	Payload		
AC	Load	2K	10K	30K	10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics									
			Fleet	Available			Sorties	Available	
Origin	Distance	C130	C130J	C17	C5	C130	C130J	C17	C5
A	6,140	60	4	62	43	24.6	1.8	34.3	23.0
B	7,440	60	4	62	43	20.6	1.5	29.3	19.8
C	2,190	60	4	62	43	59.2	4.3	73.0	46.0

Drop Type Characteristics								
Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	100	$190	3,000	0	2200
2K PBA	2K	0.95	$4,800	60	$80	15,000	0	1000
10K PBA	10K	4.50	$11,000	60	$183	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics									
	Flight Cost ($)					Rigging	Cost ($)		
AC	Origin A	Origin B	Origin C	10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	271,474	328,952	96,829	57,000	72,000	33,000	495,000	180,000	150,000
C130J	287,587	348,477	102,576	57,000	72,000	33,000	495,000	180,000	150,000
C17	359,334	435,415	128,166	228,000	192,000	132,000	1,320,000	720,000	300,000
C5	775,238	939,376	276,510	361,000	384,000	209,000	2,640,000	1,140,000	900,000

Drop Zone Requirements				
DZ	Stons	Altitude	Offset	Accuracy
D1	2550	800	0	2500
D2	2550	16000	8	300
D3	2550	8000	0	1000
D4	2550	800	0	500

		Max	Stons	
	C130	C130J	C17	C5
A	297.62	21.95	1,576.66	1,673.67
B	249.56	18.44	1,342.58	1,437.27
C	717.52	52.14	3,352.87	3,345.74
			Total	14,086.02

Solution									
		Sorties	Flown			Stons	Supplied		Total Cost
Origin	C130	C130J	C17	C5	D1	D2	D3	D4	
A	0.0	0.0	34.3	23.0	2550	2550	2550	2550	$156,080,124
B	0.0	0.0	13.3	0.0					
C	59.2	4.3	73.0	46.0					

SOPAD Requirements (Altitude, Offset, Accuracy)

D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D2	Altitude	16000	Offset	8	Accuracy	300
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	0	2200	0
2K PBA	15,000	0	0	0	1000	0
10K PBA	24,500	1	0	0	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D3	Altitude	8000	Offset	0	Accuracy	1000
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	2200	0
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	118.66	0.00
10K PBA	55.56	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	0.00	0.00	9.98
30K PGA	0.00	37.74	0.00	31.33

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	24.37	0.00	24.37	13,433,476	0	0	787	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	9.98	9.98	10,776,687	0	0	0	433
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	23.03	23.03	38,579,804	0	0	0	1,556
						$62,789,967		0	0	787	1,989
TOTAL						Sum	Cost	D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	13.26	0.00	13.26	8,320,540	0	0	428	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$8,320,540		0	0	428	0
TOTALS						Sum	Cost	D1	D2	D3	D4

Origin C	Ramstein AB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	59.24	0.00	59.24	10,001,100	0	0	718	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	4.30	0.00	4.30	751,520	0	0	52	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	17.49	0.00	17.49	5,600,260	0	0	565	0
	10K PBA	55.56	0.00	0.00	0.00	55.56	14,453,687	2,550	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	37.74	0.00	8.30	46.04	54,163,050	0	2,550	0	561
						$84,969,617		2,550	2,550	1,335	561
TOTAL						Sum Cost		D1	D2	D3	D4

Scenario 2b Solution

Aircraft Characteristics

AC	Max Load	Speed	CPFH	RTGT	RTFT Origin A	RTFT Origin B	RTFT Origin C	CT Origin A	CT Origin B	CT Origin C
C130	42,000	271	$5,991	4.5	45.3	54.9	16.2	49.8	59.4	20.7
C130J	44,000	303	$7,096	4.5	40.5	49.1	14.5	45.0	53.6	19.0
C17	170,900	405	$11,851	6.5	30.3	36.7	10.8	36.8	43.2	17.3
C5	270,000	415	$26,199	8.5	29.6	35.9	10.6	38.1	44.4	19.1

Sortie Characteristics

AC	Plan Load	System Load 2K	System Load 10K	System Load 30K	Sortie Payload 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics

Origin	Distance	Fleet Available C130	C130J	C17	C5	Sorties Available C130	C130J	C17	C5
A	6,140	60	4	62	43	24.6	1.8	34.3	23.0
B	7,440	60	4	62	43	20.6	1.5	29.3	19.8
C	2,190	60	4	62	43	59.2	4.3	73.0	46.0

Drop Type Characteristics

Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	20	$950	3,000	0	2200
2K PBA	2K	0.95	$4,800	20	$240	15,000	0	1000
10K PBA	10K	4.50	$11,000	20	$550	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics

AC	Flight Cost ($) Origin A	Origin B	Origin C	Rigging Cost ($) 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	271,474	328,952	96,829	2,850	3,600	1,650	24,750	9,000	7,500
C130J	287,587	348,477	102,576	2,850	3,600	1,650	24,750	9,000	7,500
C17	359,334	435,415	128,166	11,400	9,600	6,600	66,000	36,000	15,000
C5	775,238	939,376	276,510	18,050	19,200	10,450	132,000	57,000	45,000

Drop Zone Requirements

DZ	Stons	Altitude	Offset	Accuracy
D1	2550	800	0	2500
D2	2550	16000	8	300
D3	2550	8000	0	1000
D4	2550	800	0	500

	Max Stons C130	C130J	C17	C5
A	297.62	21.95	1,576.66	1,673.67
B	249.56	18.44	1,342.58	1,437.27
C	717.52	52.14	3,352.87	3,345.74
			Total	14,086.02

Solution

Origin	Sorties Flown C130	C130J	C17	C5	Stons Supplied D1	D2	D3	D4	Total Cost
A	0.0	0.0	34.3	3.0	2550	2550	2550	2550	$61,974,623
B	0.0	0.0	29.3	0.0					
C	59.2	4.3	73.0	46.0					

SOPAD Requirements (Altitude, Offset, Accuracy)

D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D2	Altitude	16000	Offset	8	Accuracy	300
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	0	2200	0
2K PBA	15,000	0	0	0	1000	0
10K PBA	24,500	1	0	0	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D3	Altitude	8000	Offset	0	Accuracy	1000
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	2200	0
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	63.54	0.00
10K PBA	35.09	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	53.17	38.59	58.82
30K PGA	0.00	0.00	0.00	0.00

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	34.35	0.00	34.35	13,579,714	0	0	1,489	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	2.99	0.00	0.00	2.99	2,487,277	0	205	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$16,066,991		0	205	1,489	0

Origin B		Travis AFB									
			Sorties Required			Sortie	Sortie		Stons Delivered		
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	29.25	0.00	0.00	29.25	13,788,966	0	1,268	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$13,788,966		0	1,268	0	0
TOTALS						Sum Cost		D1	D2	D3	D4

Origin C	Ramstein AB										
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	59.24	0.00	59.24	5,949,211	0	0	718	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	4.30	0.00	4.30	457,069	0	0	52	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	14.22	0.00	58.82	73.05	11,991,906	0	617	0	2,550
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	35.09	0.00	0.00	0.00	35.09	10,068,769	2,550	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	6.71	4.24	0.00	10.95	3,651,712	0	460	291	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$32,118,666		2,550	1,077	1,061	2,550
TOTAL						Sum	Cost	D1	D2	D3	D4

Scenario 2c Solution

Aircraft Characteristics

AC	Max Load	Speed	CPFH	RTGT	RTFT Origin A	RTFT Origin B	RTFT Origin C	CT Origin A	CT Origin B	CT Origin C
C130	42,000	271	$5,991	4.5	45.3	54.9	16.2	49.8	59.4	20.7
C130J	44,000	303	$7,096	4.5	40.5	49.1	14.5	45.0	53.6	19.0
C17	170,900	405	$11,851	6.5	30.3	36.7	10.8	36.8	43.2	17.3
C5	270,000	415	$26,199	8.5	29.6	35.9	10.6	38.1	44.4	19.1

Sortie Characteristics

AC	Plan Load	System Load 2K	System Load 10K	System Load 30K	Sortie Payload 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics

Origin	Distance	Fleet Available C130	C130J	C17	C5	Sorties Available C130	C130J	C17	C5
A	6,140	60	4	62	0	24.6	1.8	34.3	0.0
B	7,440	60	4	62	0	20.6	1.5	29.3	0.0
C	2,190	60	4	62	0	59.2	4.3	73.0	0.0

Drop Type Characteristics

Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	100	$190	3,000	0	2200
2K PBA	2K	0.95	$4,800	60	$80	15,000	0	1000
10K PBA	10K	4.50	$11,000	60	$183	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics

AC	Flight Cost ($) Origin A	Origin B	Origin C	Rigging Cost ($) 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	271,474	328,952	96,829	57,000	72,000	33,000	495,000	180,000	150,000
C130J	287,587	348,477	102,576	57,000	72,000	33,000	495,000	180,000	150,000
C17	359,334	435,415	128,166	228,000	192,000	132,000	1,320,000	720,000	300,000
C5	775,238	939,376	276,510	361,000	384,000	209,000	2,640,000	1,140,000	900,000

Drop Zone Requirements

DZ	Stons	Altitude	Offset	Accuracy
D1	1825	800	0	2500
D2	1825	16000	8	300
D3	1825	8000	0	1000
D4	1825	800	0	500

	Max Stons C130	C130J	C17	C5
A	297.62	21.95	1,576.66	0.00
B	249.56	18.44	1,342.58	0.00
C	717.52	52.14	3,352.87	0.00
			Total	7,629.35

Solution

Origin	Sorties Flown C130	C130J	C17	C5	Stons Supplied D1	D2	D3	D4	Total Cost
A	24.6	1.8	34.3	0.0	1825	1825	1825	1825	$134,261,331
B	20.6	1.5	29.3	0.0					
C	59.2	4.3	73.0	0.0					

SOPAD Requirements (Altitude, Offset, Accuracy)

D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D2	Altitude	16000	Offset	8	Accuracy	300
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	0	2200	0
2K PBA	15,000	0	0	0	1000	0
10K PBA	24,500	1	0	0	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D3	Altitude	8000	Offset	0	Accuracy	1000
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	2200	0
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	119.50	0.00
10K PBA	39.76	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	42.10	5.24	42.10
30K PGA	0.00	0.00	0.00	0.00

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	24.57	0.00	24.57	8,439,700	0	0	298	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	1.81	0.00	1.81	651,645	0	0	22	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	34.35	0.00	0.00	0.00	34.35	16,877,311	1,577	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$25,968,656		1,577	0	320	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties Required			Sortie	Sortie		Stons Delivered		
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	20.60	0.00	20.60	8,260,970	0	0	250	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	1.52	0.00	1.52	640,023	0	0	18	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	7.45	0.00	7.45	4,672,307	0	0	241	0
	10K PBA	5.41	0.00	0.00	0.00	5.41	3,069,925	248	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	11.15	5.24	0.00	16.39	18,940,590	0	483	227	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$35,583,815		248	483	736	0
TOTALS						Sum Cost		D1	D2	D3	D4

Origin C	Ramstein AB										
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	59.24	0.00	59.24	10,001,100	0	0	718	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	4.30	0.00	4.30	751,520	0	0	52	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	30.95	0.00	42.10	73.05	61,956,240	0	1,342	0	1,825
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$72,708,859		0	1,342	770	1,825
TOTAL						Sum Cost		D1	D2	D3	D4

Scenario 2d Solution

Aircraft Characteristics										
	Max					RTFT			CT	
AC	Load	Speed	CPFH	RTGT	Origin A	Origin B	Origin C	Origin A	Origin B	Origin C
C130	42,000	271	$5,991	4.5	45.3	54.9	16.2	49.8	59.4	20.7
C130J	44,000	303	$7,096	4.5	40.5	49.1	14.5	45.0	53.6	19.0
C17	170,900	405	$11,851	6.5	30.3	36.7	10.8	36.8	43.2	17.3
C5	270,000	415	$26,199	8.5	29.6	35.9	10.6	38.1	44.4	19.1

Sortie Characteristics										
	Plan		System Load				Sortie	Payload		
AC	Load	2K	10K	30K	10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics									
			Fleet	Available			Sorties	Available	
Origin	Distance	C130	C130J	C17	C5	C130	C130J	C17	C5
A	6,140	60	4	62	0	24.6	1.8	34.3	0.0
B	7,440	60	4	62	0	20.6	1.5	29.3	0.0
C	2,190	60	4	62	0	59.2	4.3	73.0	0.0

Drop Type Characteristics								
Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	20	$950	3,000	0	2200
2K PBA	2K	0.95	$4,800	20	$240	15,000	0	1000
10K PBA	10K	4.50	$11,000	20	$550	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics									
	Flight Cost ($)					Rigging	Cost ($)		
AC	Origin A	Origin B	Origin C	10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	271,474	328,952	96,829	2,850	3,600	1,650	24,750	9,000	7,500
C130J	287,587	348,477	102,576	2,850	3,600	1,650	24,750	9,000	7,500
C17	359,334	435,415	128,166	11,400	9,600	6,600	66,000	36,000	15,000
C5	775,238	939,376	276,510	18,050	19,200	10,450	132,000	57,000	45,000

Drop Zone Requirements				
DZ	Stons	Altitude	Offset	Accuracy
D1	1825	800	0	2500
D2	1825	16000	8	300
D3	1825	8000	0	1000
D4	1825	800	0	500

		Max	Stons	
	C130	C130J	C17	C5
A	297.62	21.95	1,576.66	0.00
B	249.56	18.44	1,342.58	0.00
C	717.52	52.14	3,352.87	0.00
			Total	7,629.35

	Solution								
		Sorties	Flown			Stons	Supplied		Total Cost
Origin	C130	C130J	C17	C5	D1	D2	D3	D4	
A	24.6	1.8	34.3	0.0	1825	1825	1825	1825	$56,983,238
B	15.3	0.0	29.3	0.0					
C	59.2	4.3	73.0	0.0					

SOPAD Requirements (Altitude, Offset, Accuracy)

D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D2	Altitude	16000	Offset	8	Accuracy	300
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	0	2200	0
2K PBA	15,000	0	0	0	1000	0
10K PBA	24,500	1	0	0	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D3	Altitude	8000	Offset	0	Accuracy	1000
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	2200	0
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	105.26	0.00
10K PBA	39.76	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	42.10	12.69	42.10
30K PGA	0.00	0.00	0.00	0.00

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	24.57	0.00	24.57	6,759,004	0	0	298	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	1.81	0.00	1.81	527,690	0	0	22	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	21.66	12.69	0.00	34.35	13,579,714	0	939	550	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$20,866,408		0	939	870	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	15.33	0.00	15.33	5,098,634	0	0	186	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	20.44	0.00	8.81	29.25	13,788,966	0	886	0	382
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$18,887,599		0	886	186	382
TOTALS						Sum	Cost	D1	D2	D3	D4

Origin C	Ramstein AB												
			Sorties	Required		Sortie	Sortie		Stons	Delivered			
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	59.24	0.00	59.24	5,949,211	0	0	718	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	4.30	0.00	4.30	457,069	0	0	52	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	39.76	0.00	0.00	0.00	39.76	5,358,358	1,825	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	33.29	33.29	5,464,594	0	0	0	1,443
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$17,229,231		1,825	0	770	1,443
TOTAL						Sum Cost		D1	D2	D3	D4

Scenario 3a Solution

Aircraft Characteristics

AC	Max Load	Speed	CPFH	RTGT	RTFT Origin A	RTFT Origin B	RTFT Origin C	CT Origin A	CT Origin B	CT Origin C
C130	42,000	271	$5,991	4.5	45.3	54.9	16.2	49.8	59.4	20.7
C130J	44,000	303	$7,096	4.5	40.5	49.1	14.5	45.0	53.6	19.0
C17	170,900	405	$11,851	6.5	30.3	36.7	10.8	36.8	43.2	17.3
C5	270,000	415	$26,199	8.5	29.6	35.9	10.6	38.1	44.4	19.1

Sortie Characteristics

AC	Plan Load	System Load 2K	System Load 10K	System Load 30K	Sortie Payload 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics

Origin	Distance	Fleet Available C130	C130J	C17	C5	Sorties Available C130	C130J	C17	C5
A	6,140	60	4	62	43	24.6	1.8	34.3	23.0
B	7,440	0	0	0	0	0.0	0.0	0.0	0.0
C	2,190	60	4	62	43	59.2	4.3	73.0	46.0

Drop Type Characteristics

Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	100	$190	3,000	0	2200
2K PBA	2K	0.95	$4,800	60	$80	15,000	0	1000
10K PBA	10K	4.50	$11,000	60	$183	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics

AC	Flight Cost ($) Origin A	Origin B	Origin C	Rigging Cost ($) 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	271,474	328,952	96,829	57,000	72,000	33,000	495,000	180,000	150,000
C130J	287,587	348,477	102,576	57,000	72,000	33,000	495,000	180,000	150,000
C17	359,334	435,415	128,166	228,000	192,000	132,000	1,320,000	720,000	300,000
C5	775,238	939,376	276,510	361,000	384,000	209,000	2,640,000	1,140,000	900,000

Drop Zone Requirements

DZ	Stons	Altitude	Offset	Accuracy
D1	2550	800	0	2500
D2	2550	16000	8	300
D3	2550	8000	0	1000
D4	2550	800	0	500

	Max Stons C130	C130J	C17	C5
A	297.62	21.95	1,576.66	1,673.67
B	0.00	0.00	0.00	0.00
C	717.52	52.14	3,352.87	3,345.74
			Total	11,038.18

Solution

Origin	Sorties Flown C130	C130J	C17	C5	Stons Supplied D1	D2	D3	D4	Total Cost
A	3.8	0.0	34.3	23.0	2550	2550	2550	2550	$157,300,942
B	0.0	0.0	0.0	0.0					
C	59.2	4.3	73.0	46.0					

SOPAD Requirements (Altitude, Offset, Accuracy)

D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D2	Altitude	16000	Offset	8	Accuracy	300
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	0	2200	0
2K PBA	15,000	0	0	0	1000	0
10K PBA	24,500	1	0	0	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D3	Altitude	8000	Offset	0	Accuracy	1000
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	2200	0
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	94.17	0.00
10K PBA	55.56	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	51.84	0.00	0.00
30K PGA	0.00	4.48	0.00	37.74

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	3.77	0.00	3.77	1,296,295	0	0	46	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	34.35	0.00	0.00	34.35	37,075,097	0	1,489	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	23.03	23.03	38,579,804	0	0	0	1,556
						$76,951,195		0	1,489	46	1,556
TOTAL						Sum	Cost	D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTALS						Sum	Cost	D1	D2	D3	D4

Origin C	Ramstein AB										
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	59.24	0.00	59.24	10,001,100	0	0	718	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	4.30	0.00	4.30	751,520	0	0	52	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	55.56	0.00	0.00	0.00	55.56	14,453,687	2,550	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	17.49	0.00	0.00	17.49	14,835,886	0	758	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	26.85	0.00	26.85	17,735,839	0	0	1,735	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	4.48	0.00	14.71	19.19	22,571,714	0	303	0	994
						$80,349,746		2,550	1,061	2,504	994
TOTAL						Sum	Cost	D1	D2	D3	D4

Scenario 3b Solution

Aircraft Characteristics

AC	Max Load	Speed	CPFH	RTGT	RTFT Origin A	RTFT Origin B	RTFT Origin C	CT Origin A	CT Origin B	CT Origin C
C130	42,000	271	$5,991	4.5	45.3	54.9	16.2	49.8	59.4	20.7
C130J	44,000	303	$7,096	4.5	40.5	49.1	14.5	45.0	53.6	19.0
C17	170,900	405	$11,851	6.5	30.3	36.7	10.8	36.8	43.2	17.3
C5	270,000	415	$26,199	8.5	29.6	35.9	10.6	38.1	44.4	19.1

Sortie Characteristics

AC	Plan Load	System Load 2K	System Load 10K	System Load 30K	Sortie Payload 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics

Origin	Distance	Fleet Available C130	C130J	C17	C5	Sorties Available C130	C130J	C17	C5
A	6,140	60	4	62	43	24.6	1.8	34.3	23.0
B	7,440	0	0	0	0	0.0	0.0	0.0	0.0
C	2,190	60	4	62	43	59.2	4.3	73.0	46.0

Drop Type Characteristics

Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	20	$950	3,000	0	2200
2K PBA	2K	0.95	$4,800	20	$240	15,000	0	1000
10K PBA	10K	4.50	$11,000	20	$550	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics

AC	Flight Cost ($) Origin A	Origin B	Origin C	Rigging Cost ($) 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	271,474	328,952	96,829	2,850	3,600	1,650	24,750	9,000	7,500
C130J	287,587	348,477	102,576	2,850	3,600	1,650	24,750	9,000	7,500
C17	359,334	435,415	128,166	11,400	9,600	6,600	66,000	36,000	15,000
C5	775,238	939,376	276,510	18,050	19,200	10,450	132,000	57,000	45,000

Drop Zone Requirements

DZ	Stons	Altitude	Offset	Accuracy
D1	2550	800	0	2500
D2	2550	16000	8	300
D3	2550	8000	0	1000
D4	2550	800	0	500

	Max Stons C130	C130J	C17	C5
A	297.62	21.95	1,576.66	1,673.67
B	0.00	0.00	0.00	0.00
C	717.52	52.14	3,352.87	3,345.74
			Total	11,038.18

Solution

Origin	Sorties Flown C130	C130J	C17	C5	Stons Supplied D1	D2	D3	D4	Total Cost
A	0.0	0.0	34.3	21.5	2550	2550	2550	2550	$63,560,258
B	0.0	0.0	0.0	0.0					
C	59.2	4.3	73.0	46.0					

SOPAD Requirements (Altitude, Offset, Accuracy)

D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D2	Altitude	16000	Offset	8	Accuracy	300
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	0	2200	0
2K PBA	15,000	0	0	0	1000	0
10K PBA	24,500	1	0	0	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D3	Altitude	8000	Offset	0	Accuracy	1000
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	2200	0
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	63.54	0.00
10K PBA	35.09	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	46.30	34.68	58.82
30K PGA	0.00	0.00	0.00	0.00

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	10.62	23.73	0.00	34.35	13,579,714	0	460	1,029	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	21.46	0.00	0.00	21.46	17,861,878	0	1,473	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$31,441,592		0	1,933	1,029	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTALS						Sum	Cost	D1	D2	D3	D4

Origin C	Ramstein AB										
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	59.24	0.00	59.24	5,949,211	0	0	718	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	4.30	0.00	4.30	457,069	0	0	52	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	14.22	0.00	58.82	73.05	11,991,906	0	617	0	2,550
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	35.09	0.00	0.00	0.00	35.09	10,068,769	2,550	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	10.95	0.00	10.95	3,651,712	0	0	752	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$32,118,666		2,550	617	1,521	2,550
TOTAL						Sum	Cost	D1	D2	D3	D4

Scenario 3c Solution

Aircraft Characteristics

AC	Max Load	Speed	CPFH	RTGT	RTFT Origin A	RTFT Origin B	RTFT Origin C	CT Origin A	CT Origin B	CT Origin C
C130	42,000	271	$5,991	4.5	45.3	54.9	16.2	49.8	59.4	20.7
C130J	44,000	303	$7,096	4.5	40.5	49.1	14.5	45.0	53.6	19.0
C17	170,900	405	$11,851	6.5	30.3	36.7	10.8	36.8	43.2	17.3
C5	270,000	415	$26,199	8.5	29.6	35.9	10.6	38.1	44.4	19.1

Sortie Characteristics

AC	Plan Load	System Load 2K	System Load 10K	System Load 30K	Sortie Payload 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics

Origin	Distance	Fleet Available C130	C130J	C17	C5	Sorties Available C130	C130J	C17	C5
A	6,140	60	4	62	0	24.6	1.8	34.3	0.0
B	7,440	0	0	0	0	0.0	0.0	0.0	0.0
C	2,190	60	4	62	0	59.2	4.3	73.0	0.0

Drop Type Characteristics

Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	100	$190	3,000	0	2200
2K PBA	2K	0.95	$4,800	60	$80	15,000	0	1000
10K PBA	10K	4.50	$11,000	60	$183	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics

AC	Flight Cost ($) Origin A	Origin B	Origin C	Rigging Cost ($) 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	271,474	328,952	96,829	57,000	72,000	33,000	495,000	180,000	150,000
C130J	287,587	348,477	102,576	57,000	72,000	33,000	495,000	180,000	150,000
C17	359,334	435,415	128,166	228,000	192,000	132,000	1,320,000	720,000	300,000
C5	775,238	939,376	276,510	361,000	384,000	209,000	2,640,000	1,140,000	900,000

Drop Zone Requirements

DZ	Stons	Altitude	Offset	Accuracy
D1	1450	800	0	2500
D2	1450	16000	8	300
D3	1450	8000	0	1000
D4	1450	800	0	500

	Max Stons C130	C130J	C17	C5
A	297.62	21.95	1,576.66	0.00
B	0.00	0.00	0.00	0.00
C	717.52	52.14	3,352.87	0.00
			Total	6,018.77

Solution

Origin	Sorties Flown C130	C130J	C17	C5	Stons Supplied D1	D2	D3	D4	Total Cost
A	24.6	1.8	34.3	0.0	1450	1450	1450	1450	$99,083,392
B	0.0	0.0	0.0	0.0					
C	59.2	4.3	73.0	0.0					

SOPAD Requirements (Altitude, Offset, Accuracy)						
D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1
D2	Altitude	16000	Offset	8	Accuracy	300
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	0	2200	0
2K PBA	15,000	0	0	0	1000	0
10K PBA	24,500	1	0	0	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1
D3	Altitude	8000	Offset	0	Accuracy	1000
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	2200	0
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1
D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType				
	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	92.23	0.00
10K PBA	31.59	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	33.45	6.61	33.45
30K PGA	0.00	0.00	0.00	0.00

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	24.57	0.00	24.57	8,439,700	0	0	298	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	1.81	0.00	1.81	651,645	0	0	22	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	2.30	0.00	2.30	1,270,518	0	0	74	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	25.44	6.61	0.00	32.05	34,587,833	0	1,103	286	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$44,949,696		0	1,103	680	0
TOTAL						Sum Cost		D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties Required			Sortie	Sortie		Stons Delivered		
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTALS						Sum Cost		D1	D2	D3	D4

Origin C	Ramstein AB										
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	59.24	0.00	59.24	10,001,100	0	0	718	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	4.30	0.00	4.30	751,520	0	0	52	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	31.59	0.00	0.00	0.00	31.59	8,218,763	1,450	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	8.01	0.00	33.45	41.46	35,162,313	0	347	0	1,450
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$54,133,696		1,450	347	770	1,450
TOTAL						Sum Cost		D1	D2	D3	D4

Scenario 3d Solution

Aircraft Characteristics

	Max				RTFT			CT		
AC	Load	Speed	CPFH	RTGT	Origin A	Origin B	Origin C	Origin A	Origin B	Origin C
C130	42,000	271	$5,991	4.5	45.3	54.9	16.2	49.8	59.4	20.7
C130J	44,000	303	$7,096	4.5	40.5	49.1	14.5	45.0	53.6	19.0
C17	170,900	405	$11,851	6.5	30.3	36.7	10.8	36.8	43.2	17.3
C5	270,000	415	$26,199	8.5	29.6	35.9	10.6	38.1	44.4	19.1

Sortie Characteristics

	Plan	System Load			Sortie Payload					
AC	Load	2K	10K	30K	10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics

		Fleet Available				Sorties Available			
Origin	Distance	C130	C130J	C17	C5	C130	C130J	C17	C5
A	6,140	60	4	62	0	24.6	1.8	34.3	0.0
B	7,440	0	0	0	0	0.0	0.0	0.0	0.0
C	2,190	60	4	62	0	59.2	4.3	73.0	0.0

Drop Type Characteristics

Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	20	$950	3,000	0	2200
2K PBA	2K	0.95	$4,800	20	$240	15,000	0	1000
10K PBA	10K	4.50	$11,000	20	$550	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics

	Flight Cost ($)			Rigging Cost ($)					
AC	Origin A	Origin B	Origin C	10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	271,474	328,952	96,829	2,850	3,600	1,650	24,750	9,000	7,500
C130J	287,587	348,477	102,576	2,850	3,600	1,650	24,750	9,000	7,500
C17	359,334	435,415	128,166	11,400	9,600	6,600	66,000	36,000	15,000
C5	775,238	939,376	276,510	18,050	19,200	10,450	132,000	57,000	45,000

Drop Zone Requirements

DZ	Stons	Altitude	Offset	Accuracy
D1	1450	800	0	2500
D2	1450	16000	8	300
D3	1450	8000	0	1000
D4	1450	800	0	500

	Max Stons			
	C130	C130J	C17	C5
A	297.62	21.95	1,576.66	0.00
B	0.00	0.00	0.00	0.00
C	717.52	52.14	3,352.87	0.00
			Total	6,018.77

Solution

	Sorties Flown				Stons Supplied				Total Cost
Origin	C130	C130J	C17	C5	D1	D2	D3	D4	
A	24.3	0.0	34.3	0.0	1450	1450	1450	1450	$37,728,347
B	0.0	0.0	0.0	0.0					
C	59.2	4.3	73.0	0.0					

SOPAD Requirements (Altitude, Offset, Accuracy)

D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D2	Altitude	16000	Offset	8	Accuracy	300
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	0	2200	0
2K PBA	15,000	0	0	0	1000	0
10K PBA	24,500	1	0	0	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D3	Altitude	8000	Offset	0	Accuracy	1000
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	2200	0
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	87.82	0.00
10K PBA	31.59	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	33.45	8.91	33.45
30K PGA	0.00	0.00	0.00	0.00

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	24.28	0.00	24.28	6,679,207	0	0	294	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	33.45	0.90	0.00	34.35	13,579,714	0	1,450	39	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$20,258,920		0	1,450	333	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTALS						Sum	Cost	D1	D2	D3	D4

Origin C	Ramstein AB										
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	59.24	0.00	59.24	5,949,211	0	0	718	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	4.30	0.00	4.30	457,069	0	0	52	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	31.59	0.00	0.00	0.00	31.59	4,257,325	1,450	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	8.01	33.45	41.46	6,805,822	0	0	347	1,450
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$17,469,427		1,450	0	1,117	1,450
TOTAL						Sum	Cost	D1	D2	D3	D4

Scenario 3e Solution

Aircraft Characteristics										
	Max					RTFT			CT	
AC	Load	Speed	CPFH	RTGT	Origin A	Origin B	Origin C	Origin A	Origin B	Origin C
C130	42,000	271	$5,991	4.5	51.2	41.3	39.5	55.7	45.8	44.0
C130J	44,000	303	$7,096	4.5	45.8	37.0	35.3	50.3	41.5	39.8
C17	170,900	405	$11,851	6.5	34.3	27.7	26.4	40.8	34.2	32.9
C5	270,000	415	$26,199	8.5	33.4	27.0	25.8	41.9	35.5	34.3

Sortie Characteristics										
	Plan		System Load				Sortie	Payload		
AC	Load	2K	10K	30K	10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics									
			Fleet	Available			Sorties	Available	
Origin	Distance	C130	C130J	C17	C5	C130	C130J	C17	C5
A	6,940	0	0	0	0	0.0	0.0	0.0	0.0
B	5,600	60	4	62	43	26.7	2.0	37.0	24.7
C	5,350	0	0	0	0	0.0	0.0	0.0	0.0

Drop Type Characteristics								
Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	100	$190	3,000	0	2200
2K PBA	2K	0.95	$4,800	60	$80	15,000	0	1000
10K PBA	10K	4.50	$11,000	60	$183	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics									
		Flight Cost ($)				Rigging	Cost ($)		
AC	Origin A	Origin B	Origin C	10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	306,845	247,599	236,545	57,000	72,000	33,000	495,000	180,000	150,000
C130J	325,058	262,294	250,585	57,000	72,000	33,000	495,000	180,000	150,000
C17	406,153	327,731	313,100	228,000	192,000	132,000	1,320,000	720,000	300,000
C5	876,246	707,057	675,492	361,000	384,000	209,000	2,640,000	1,140,000	900,000

Drop Zone Requirements				
DZ	Stons	Altitude	Offset	Accuracy
D1	850	800	0	2500
D2	850	16000	8	300
D3	850	8000	0	1000
D4	850	800	0	500

		Max	Stons	
	C130	C130J	C17	C5
A	0.00	0.00	0.00	0.00
B	323.50	23.84	1,699.77	1,796.40
C	0.00	0.00	0.00	0.00
			Total	3,843.51

	Solution								
		Sorties	Flown			Stons	Supplied		Total Cost
Origin	C130	C130J	C17	C5	D1	D2	D3	D4	
A	0.0	0.0	0.0	0.0	850	850	850	850	$64,664,882
B	9.2	0.0	37.0	24.7					
C	0.0	0.0	0.0	0.0					

SOPAD Requirements (Altitude, Offset, Accuracy)						
D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1
D2	Altitude	16000	Offset	8	Accuracy	300
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	0	2200	0
2K PBA	15,000	0	0	0	1000	0
10K PBA	24,500	1	0	0	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1
D3	Altitude	8000	Offset	0	Accuracy	1000
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	2200	0
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1
D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType				
	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	20.61	0.00
10K PBA	18.52	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	18.51	0.00	0.00
30K PGA	0.00	0.70	0.00	12.58

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	9.18	0.00	9.18	2,932,396	0	0	111	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	18.52	0.00	0.00	0.00	18.52	8,513,544	850	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	18.51	0.00	0.00	18.51	19,397,069	0	803	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	11.44	0.00	11.44	12,479,007	0	0	739	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.70	0.00	12.58	13.28	21,342,867	0	47	0	850
						$64,664,882		850	850	850	850
TOTALS						Sum	Cost	D1	D2	D3	D4

Origin C	Ramstein AB										
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Scenario 3f Solution

Aircraft Characteristics

AC	Max Load	Speed	CPFH	RTGT	RTFT Origin A	RTFT Origin B	RTFT Origin C	CT Origin A	CT Origin B	CT Origin C
C130	42,000	271	$5,991	4.5	51.2	41.3	39.5	55.7	45.8	44.0
C130J	44,000	303	$7,096	4.5	45.8	37.0	35.3	50.3	41.5	39.8
C17	170,900	405	$11,851	6.5	34.3	27.7	26.4	40.8	34.2	32.9
C5	270,000	415	$26,199	8.5	33.4	27.0	25.8	41.9	35.5	34.3

Sortie Characteristics

AC	Plan Load	System Load 2K	System Load 10K	System Load 30K	Sortie Payload 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics

Origin	Distance	Fleet Available C130	C130J	C17	C5	Sorties Available C130	C130J	C17	C5
A	6,940	0	0	0	0	0.0	0.0	0.0	0.0
B	5,600	60	4	62	43	26.7	2.0	37.0	24.7
C	5,350	0	0	0	0	0.0	0.0	0.0	0.0

Drop Type Characteristics

Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	20	$950	3,000	0	2200
2K PBA	2K	0.95	$4,800	20	$240	15,000	0	1000
10K PBA	10K	4.50	$11,000	20	$550	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics

AC	Flight Cost ($) Origin A	Origin B	Origin C	Rigging Cost ($) 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	306,845	247,599	236,545	2,850	3,600	1,650	24,750	9,000	7,500
C130J	325,058	262,294	250,585	2,850	3,600	1,650	24,750	9,000	7,500
C17	406,153	327,731	313,100	11,400	9,600	6,600	66,000	36,000	15,000
C5	876,246	707,057	675,492	18,050	19,200	10,450	132,000	57,000	45,000

Drop Zone Requirements

DZ	Stons	Altitude	Offset	Accuracy
D1	850	800	0	2500
D2	850	16000	8	300
D3	850	8000	0	1000
D4	850	800	0	500

	Max Stons C130	C130J	C17	C5
A	0.00	0.00	0.00	0.00
B	323.50	23.84	1,699.77	1,796.40
C	0.00	0.00	0.00	0.00
			Total	3,843.51

Solution

Origin	Sorties Flown C130	C130J	C17	C5	Stons Supplied D1	D2	D3	D4	Total Cost
A	0.0	0.0	0.0	0.0	850	850	850	850	$32,865,856
B	4.2	0.0	37.0	24.7					
C	0.0	0.0	0.0	0.0					

SOPAD Requirements (Altitude, Offset, Accuracy)

D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D2	Altitude	16000	Offset	8	Accuracy	300
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	0	2200	0
2K PBA	15,000	0	0	0	1000	0
10K PBA	24,500	1	0	0	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D3	Altitude	8000	Offset	0	Accuracy	1000
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	2200	0
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	4.20	0.00
10K PBA	18.52	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	12.38	11.64	19.20
30K PGA	0.00	0.00	0.00	0.00

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties Required			Sortie	Sortie		Stons Delivered		
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	4.20	0.00	4.20	1,054,472	0	0	51	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	18.52	0.00	0.00	0.00	18.52	6,191,321	850	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	18.51	18.51	6,733,904	0	0	0	803
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	12.38	11.64	0.69	24.72	18,886,159	0	850	799	47
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$32,865,856		850	850	850	850
TOTALS						Sum Cost		D1	D2	D3	D4

Origin C	Ramstein AB										
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Scenario 3g Solution

Aircraft Characteristics

AC	Max Load	Speed	CPFH	RTGT	RTFT Origin A	RTFT Origin B	RTFT Origin C	CT Origin A	CT Origin B	CT Origin C
C130	42,000	271	$5,991	4.5	51.2	41.3	39.5	55.7	45.8	44.0
C130J	44,000	303	$7,096	4.5	45.8	37.0	35.3	50.3	41.5	39.8
C17	170,900	405	$11,851	6.5	34.3	27.7	26.4	40.8	34.2	32.9
C5	270,000	415	$26,199	8.5	33.4	27.0	25.8	41.9	35.5	34.3

Sortie Characteristics

AC	Plan Load	System Load 2K	System Load 10K	System Load 30K	Sortie Payload 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics

Origin	Distance	Fleet Available C130	C130J	C17	C5	Sorties Available C130	C130J	C17	C5
A	6,940	0	0	0	0	0.0	0.0	0.0	0.0
B	5,600	60	4	62	0	26.7	2.0	37.0	0.0
C	5,350	0	0	0	0	0.0	0.0	0.0	0.0

Drop Type Characteristics

Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	100	$190	3,000	0	2200
2K PBA	2K	0.95	$4,800	60	$80	15,000	0	1000
10K PBA	10K	4.50	$11,000	60	$183	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics

AC	Flight Cost ($) Origin A	Origin B	Origin C	Rigging Cost ($) 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	306,845	247,599	236,545	57,000	72,000	33,000	495,000	180,000	150,000
C130J	325,058	262,294	250,585	57,000	72,000	33,000	495,000	180,000	150,000
C17	406,153	327,731	313,100	228,000	192,000	132,000	1,320,000	720,000	300,000
C5	876,246	707,057	675,492	361,000	384,000	209,000	2,640,000	1,140,000	900,000

Drop Zone Requirements

DZ	Stons	Altitude	Offset	Accuracy
D1	475	800	0	2500
D2	475	16000	8	300
D3	475	8000	0	1000
D4	475	800	0	500

	Max Stons C130	C130J	C17	C5
A	0.00	0.00	0.00	0.00
B	323.50	23.84	1,699.77	0.00
C	0.00	0.00	0.00	0.00
			Total	2,047.11

Solution

Origin	Sorties Flown C130	C130J	C17	C5	Stons Supplied D1	D2	D3	D4	Total Cost
A	0.0	0.0	0.0	0.0	475	475	475	475	$38,665,771
B	26.5	0.0	37.0	0.0					
C	0.0	0.0	0.0	0.0					

SOPAD Requirements (Altitude, Offset, Accuracy)

D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D2	Altitude	16000	Offset	8	Accuracy	300
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	0	2200	0
2K PBA	15,000	0	0	0	1000	0
10K PBA	24,500	1	0	0	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D3	Altitude	8000	Offset	0	Accuracy	1000
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	2200	0
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	31.27	0.00
10K PBA	10.35	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	10.96	0.00	10.96
30K PGA	0.00	0.00	0.00	0.00

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	26.50	0.00	26.50	8,469,103	0	0	321	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	4.77	0.00	4.77	2,478,435	0	0	154	0
	10K PBA	10.35	0.00	0.00	0.00	10.35	4,757,569	475	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	10.96	0.00	10.96	21.91	22,960,664	0	475	0	475
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$38,665,771		475	475	475	475
TOTALS						Sum	Cost	D1	D2	D3	D4

Origin C	Ramstein AB										
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Scenario 3h Solution

Aircraft Characteristics

AC	Max Load	Speed	CPFH	RTGT	RTFT Origin A	RTFT Origin B	RTFT Origin C	CT Origin A	CT Origin B	CT Origin C
C130	42,000	271	$5,991	4.5	51.2	41.3	39.5	55.7	45.8	44.0
C130J	44,000	303	$7,096	4.5	45.8	37.0	35.3	50.3	41.5	39.8
C17	170,900	405	$11,851	6.5	34.3	27.7	26.4	40.8	34.2	32.9
C5	270,000	415	$26,199	8.5	33.4	27.0	25.8	41.9	35.5	34.3

Sortie Characteristics

AC	Plan Load	System Load 2K	System Load 10K	System Load 30K	Sortie Payload 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	30,000	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C130J	31,429	15	3	1	11.48	12.11	11.48	11.48	10.84	11.26
C17	122,071	40	12	2	45.90	32.30	45.90	30.60	43.35	22.53
C5	192,857	80	19	6	72.68	64.60	72.68	61.20	68.64	67.58

Origin Characteristics

Origin	Distance	Fleet Available C130	C130J	C17	C5	Sorties Available C130	C130J	C17	C5
A	6,940	0	0	0	0	0.0	0.0	0.0	0.0
B	5,600	60	4	62	0	26.7	2.0	37.0	0.0
C	5,350	0	0	0	0	0.0	0.0	0.0	0.0

Drop Type Characteristics

Drop Type	Rig Wt	Payload	Sys Cost	Life Span	Use Cost	Altitude	Offset	Accuracy
10K CAD	10K	4.50	$19,000	20	$950	3,000	0	2200
2K PBA	2K	0.95	$4,800	20	$240	15,000	0	1000
10K PBA	10K	4.50	$11,000	20	$550	24,500	0	2200
2K PGA	2K	0.90	$33,000	20	$1,650	24,500	20	150
10K PGA	10K	4.25	$60,000	20	$3,000	24,500	8	250
30K PGA	30K	13.25	$150,000	20	$7,500	24,500	8	300

Planning	Data
Window	24
MICAP	0.8
Q Effiency	0.85
Load X	5/7
Drop Loss	0.85
"M"	1,000

Cost Characteristics

AC	Flight Cost ($) Origin A	Origin B	Origin C	Rigging Cost ($) 10K CAD	2K PBA	10K PBA	2K PGA	10K PGA	30K PGA
C130	306,845	247,599	236,545	2,850	3,600	1,650	24,750	9,000	7,500
C130J	325,058	262,294	250,585	2,850	3,600	1,650	24,750	9,000	7,500
C17	406,153	327,731	313,100	11,400	9,600	6,600	66,000	36,000	15,000
C5	876,246	707,057	675,492	18,050	19,200	10,450	132,000	57,000	45,000

Drop Zone Requirements

DZ	Stons	Altitude	Offset	Accuracy
D1	475	800	0	2500
D2	475	16000	8	300
D3	475	8000	0	1000
D4	475	800	0	500

	Max Stons C130	C130J	C17	C5
A	0.00	0.00	0.00	0.00
B	323.50	23.84	1,699.77	0.00
C	0.00	0.00	0.00	0.00
			Total	2,047.11

Solution

Origin	Sorties Flown C130	C130J	C17	C5
A	0.0	0.0	0.0	0.0
B	22.1	0.0	37.0	0.0
C	0.0	0.0	0.0	0.0

Stons Supplied D1	D2	D3	D4	Total Cost
475	475	475	475	$18,729,170

SOPAD Requirements (Altitude, Offset, Accuracy)

D1	Altitude	800	Offset	0	Accuracy	2500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	1
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	1
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D2	Altitude	16000	Offset	8	Accuracy	300
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	0	2200	0
2K PBA	15,000	0	0	0	1000	0
10K PBA	24,500	1	0	0	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D3	Altitude	8000	Offset	0	Accuracy	1000
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	0	0	1	2200	0
2K PBA	15,000	1	0	1	1000	1
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

D4	Altitude	800	Offset	0	Accuracy	500
	≤	Y=1/N=0	≤	Y=1/N=0	≥	Y=1/N=0
10K CAD	3,000	1	0	1	2200	0
2K PBA	15,000	1	0	1	1000	0
10K PBA	24,500	1	0	1	2200	0
2K PGA	24,500	1	20	1	150	1
10K PGA	24,500	1	8	1	250	1
30K PGA	24,500	1	8	1	300	1

Sorties by DropType

	D1	D2	D3	D4
10K CAD	0.00	0.00	0.00	0.00
2K PBA	0.00	0.00	22.15	0.00
10K PBA	10.35	0.00	0.00	0.00
2K PGA	0.00	0.00	0.00	0.00
10K PGA	0.00	10.96	4.77	10.96
30K PGA	0.00	0.00	0.00	0.00

Origin A		Dover AFB									
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Origin B		Travis AFB									
			Sorties Required			Sortie	Sortie		Stons Delivered		
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	22.15	0.00	22.15	5,563,749	0	0	268	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	10.35	0.00	0.00	0.00	10.35	3,459,856	475	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	10.96	4.77	10.96	26.68	9,705,565	0	475	207	475
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
						$18,729,170		475	475	475	475
TOTALS						Sum Cost		D1	D2	D3	D4

Origin C	Ramstein AB										
			Sorties	Required		Sortie	Sortie		Stons	Delivered	
Aircraft	Drop Type	D1	D2	D3	D4	Sum	Cost	D1	D2	D3	D4
C130	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C130J	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C17	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
C5	10K CAD	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PBA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	2K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	10K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
	30K PGA	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0
							$0	0	0	0	0
TOTAL						Sum	Cost	D1	D2	D3	D4

Bibliography

"Advanced Air Mobility Concept Seminar (Precision Airdrop) Final Report." *AF A8XC.* July 2006.

"Aerial Delivery Distribution in the Theater of Operations." Headquarters Department of the Army FM 4-20.41. August 2003

"AFI 13-217, Drop Zone and Landing Zone Operations." *AFDPO webpage.* May 2007. http://www.epublishing.af.mil

"AFPAM 10-1403, Air Mobility Planning Factors." *AFDPO webpage.* December 2003. http://www.epublishing.af.mil

"ATI – Airdrop Systems, Equipment and Training." *AirForce-Technology webpage.* 16 December 2007. http://www.airforce-technology.com/contractors/airlift/airlift/

"Affordable Guided Airdrop System." *Capewell webpage.* 2 March 2007. www.capewell.com/AGASFact.pdf

"Airlift Operations." Air Force Doctrine Document 2-6.1. November 1999.

Banks, J., J. Carson, B. Nelson, and D. Nicol, "Discrete-Event System Simulation, 4th Ed." *Prentice Hall*, 2005

Benney, Richard. "AMC Tech Day: JPADS ACTD & Related Programs" *PowerPoint Briefing*. 3 June 2005 https://airdrop.natick.army.mil/ACTD/Documents_actd.htm

Benney, Richard, Joseph McGrath, Jaclyn McHugh, Andrew Meloni, Greg Noetscher, and Steve Tavan. "DOD JPADS Program Overview and NATO Activities." May 2007.

Benney, Richard. USA AMC Natick Soldier Center. Electronic Message. 3 Novemeber 2007.

Beaubien, Seth. "Rethinking Strategic Brigade Airdrop." *Graduate Research Project*. Air Force Institute of Technology, Wright-Patterson AFB OH, April 1997.

Box, George and Draper, Norman . "Empirical Model-Building and Response Surfaces." *Wiley*. January 1987

Carrabba, Pete. "The Right Place at the Right Time: An Analysis of High Altitude Airdrop and the Joint Precision Airdrop System." *Graduate Research*

Project. Air Force Institute of Technology, Wright-Patterson AFB OH, June 2004.

"Container Delivery System." *Global Security Webpage*. July 2007. http://www.globalsecurity.org/military/systems/aircraft/systems/cds.htm

Coy, John. "US DoD and NATO Precision Airdrop Overview" *PowerPoint Briefing.* 22 October 2007

Crawley, Erin. "Air Force Research Provides Seed to High-Tech Cargo Delivery System." *Air Force Research Laboratory Webpage*. 11 Jan 2007. http://www.afosr.af.mil/News/nr_2007_01_JPADS.htm

Cupp, Jon. "JPADS to Change the Future of Joint Aerial Deliveries for Warfighters." *United States Joint Forces Command Webpage*. 10 November 2005. http://www.jfcom.mil/newslink/storyarchive/2005/pa060605.htm

Daniel, Eric. "Up in the Sky: Sherpa Guided Parachute Cargo System." *Military.Com Weppage*. 10 November 2005. http://www.military.com/soldiertech/0,14632,Soldiertech_SHERPA,,00.html

"Defense Secretary Robert Gates Says 100,000 Troop Level Possible in Iraq by End of '08." *Fox News webpage.* 14 September 2007. http://www.foxnews.com/printer_freindly_story/0,3566,296868,00.html

"Department of Defense Joint Precision Airdrop Systems (JPADS) Programs." *United States Army NATICK Soldeir Center Trifold, REV 05-01-06 OPSEC 06-131*, 20 February 2006. nsrdec.natick.army.mil/media/print/JPADS_trifold.pdf

" DOD Base Realignment and Closure: 2005 BRAC Commission FY 07 Budget Estimates." *Defense Link Webpage.* 29 December 2007. http://www.defenselink.mil/comptroller/defbudget/fy2007/budgetjustification/index.html

Diaz, Carlos. "First JPADS Improved System Airdrop Over Iraq a Success." *Air Force News*. 2 February 2007. http://www.af.mil/news/story.asp?id=123041573

Dilanian, Arpi, Michael Martin and Peter Thede. "Joint Precision Airdrop System: Operational Analysis." *LMI Government Consulting*. April 2006.

Durden, Kimberlee. HQ AMC/A4PM. Electronic message. 27 February 2008.

Everdeen, Bob. "Airdrop System Protects Airmen, Soldiers." *Air Force News*. 19 October 2006. http://www.spacewar.com/reports/Airdrop_System_Protects_Airmen_Soldiers_999.html

"Factsheets." *Air Force Link Webpage*. 29 December 2007. http://www.af.mil/factsheets/

Fellows, James, Michael Harner, Jennifer Pickett, and Michael Welch. "Airlift 2025: The First with the Most." *Air University*. June 1996.

Fields, Thomas, Andrew Hoots and James Mcelwee. AMC/A3VX. Telephone correspondence. 18 July 2007

Garretson, Peter. "High-Altitude Intercontinental Precision Airdrop: A Revolution in Mobility Affairs (Could AMC Learn from the B-2 PGM Model?)" *Air Force Journal of Logistics, 29 no. 1* pag. 39-42. Spring 2005.

Garretson, Peter. HQ AF/A8XC. Electronic message. 3 July 2007.

George, Kelly. "First I-CDS, JPADS Instructor Training Begins." *Little Rock Air Force Base Webpage*. 17 Nov 2006. http://www.littlerock.af.mil/news/story.asp?storyID=123032678

George, Sean. "Aerodynamic Decelerators, Guided Airdrop Systems." *Aerospace America*, pag. 12-13. December 2006. http://www.aiaa.org/pdf/inside/06_TC_Highlights/aiaa-ads.pdf

Granger, Julian, Ananth Krishnamurthy and Stephen Robinson. "Stochastic Modeling of Airlift Operations." *Proceedings of 2001 Winter Simulation Conference*. 2001

"Heritage to Horizons: The Book 2007." *Airman Magazine*. 2007 http://www.af.mil/news/airman/0307/downloads.shtml

Heaton, Tyrell. "JPADS Revolutionizes Airdrop Missions." *Northstar Guardian Online*. 16 February 2007. http://www.minnesotanationalguard.org/press_room/e-zine/articles/index.php?item=454

"Heavy Expanded Mobility Tactical Truck." *Army Fact File*. 3 March 2007. http://www.army.mil/fact_files_site/hemtt/index.html

Ireland, Christopher. "Why Not Airdrop? The Utility of Preplanned Airdrop to Resupply Land Forces in the Contemporary Operating Environment." *USA Command and General Staff College Monograph*. May 2006.

"Joint Precision Airdrop System (JPADS)." *Global Security Webpage*. July 2007. http://www.globalsecurity.org/military/systems/aircraft/systems/jpads.htm

Kim, Kwang-Tae. "North Korea blasts US-South Korea Drills." *The State webpage*. 7 February 2008. http://thestate.com/372/story/310073.html

King, Dennis. "Look Out Below! An Analysis of the Joint Precision Airdrop System with 2K Precision Parachute Systems." *Graduate Research Project*. Air Force Institute of Technology, Wright-Patterson AFB OH, July 2006.

Kirsteatter, Gary, Zbigniew Majchrzak, Michael Martin, and Donna Simkins. "Medium and Heavy Precision Airdrop: An Operational Analysis." *LMI Government Consulting*. September 2006.

Kissel, Margo. "Wright-Pat Helps Develop 'Smart Drops'." *Dayton Daily News*, pag A1, A6. 12 February 2007. http://www.daytondailynews.com/search/content/oh/story/news/local/2007/02/11/sns021207smart.html

Kurle, David. "Bagram C-130s Drop High-Tech Cargo Delivery System." *Air Force News*. 1 September 2006. http://www.af.mil/news/story.asp?storyID=123026339

"LAPES." Excerpt from an unpublished article. 28 February 2007. http://www.parachutehistory.com/military/lapes.html

Lisbon, Bill. "GPS-Guided Paradrop." *Special Operations Technology Online Edition*, Volume 2, Issue 6. 13 September 2004. http://www.special-operations-technology.com/print_article.cfm?DocID=609

Martin, Scott. USA AMC Natick Soldier Center. Electronic Message. 11 February 2008.

McGee, Thomas. "JPADS AOR Update." *AMC A3D PowerPoint Slide*. August 2007.

McGowan, Laura. "Resupply the Warrior; Protect the Messenger." *Air Force Materiel Command Webpage.* 11 August 2006. http://www.afmc.af.mil/news/story.asp?storyID=123025045

Michaels, Jim. "Attacks Rise on Supply Convoys." *USA Today*. July 2007. http://usatoday.com/news/world/iraq/2007-07-08-convoys_N.htm

Miller, Roger. "To Save a City: The Berlin Airlift 1948-1949." *Air Force History and Museums Program*. 1998

Mink, O.J. "Meet the Parachute." *Reliance Manufacturing Company,* 97 pag. 1944.

"MMIST Sherpa." *MMIST webpage*, n.pag. 3 March 2007. http://mmist.ca/Sherpa.asp

"Para-Flight Selected to Develop 30,000lb Joint Precision Airdrop System." *Airborne Systems Press Release webpage*. 3 January 2006. http://www.asglobal.com/press.htm#PressRelease5

Ragsdale, Cliff. "Spreadsheet Modeling and Decision Analysis: A Practical Introduction to Management Science, 5th Ed." *Thomson South-Western*. 2007

"Reimbursable Rates Fixed Wing FY 2008." *Office of the Undersecretary of Defense (Comptroller) webpage*. 7 January 2008. http://www.defenselink.mil/comptroller /rates/fy2008/2008_f.pdf

"Screamer Precision Cargo Delivery System." *Strong Enterprises webpage*. 3 March 2007. http://www.strongparachutes.com/Pages/mil_screamer_cargo.htm

"STARA Technologies Incorporated." *STARA Technologies webpage*. 14 December 2007. http://www.stara.biz/index.html

Stucker, James P. and Williams, Laura M. "Analyzing the Effects of Airfield Resources on Airlift Capacity." *RAND National Defense Research Institute*. 1999

Sturkol, Scott. "JPADS Continues 'Revolution in Airdrop Technology'." *Air Force News*. 18 January 2007. http://www.af.mil/news/story.asp?storyID=123037942

Tirpak, John A. "Saving the Galaxy." *Air Force Magazine Online*. January 2004. http://www.afa.org/magazine/jan2004/0104galaxy.asp

"U.S. Centennial of Flight Commission: The Berlin Airlift." *Centennial of Flight webpage*. 11 December 2007. http://www.centennialofflight.gov/essay/Air_Power/berlin_airlift/AP35.htm

VandenBrook, Tom. "'Smart' Airdrops May Save Lives of U.S. Troops." *USA Today*. 8 January 2007. http://www.usatoday.com/news/world/iraq/2007-01-07-chute_x.htm

Varner, Michael. "Simulation Evaluation of the Combat Value of a Standoff Precision Airdrop Capability." *Thesis*, Air Force Institute of Technology, Wright-Patterson AFB OH. July 2000.

Vaughan, David and Donoho, James. "From Stalingrad to Khe Sanh: Factors in the Successful Use of Tactical Airlift to Support Isolated Land Battle Areas." *Air & Space Power Journal*. October 2000. http://www.airpower.au.af.mil/airchronicles/cc/vaughan.html

Whitaker, Jerry. "Joint Precision Airdrop Takes Flight." *Natick Press Release*. 13 October 2006. http://www.natick.army.mil/about/pao/2006/06-40.htm

Wragg, David. "Airlift: A History of Military Air Transport." *Presidio Press*. 1986.

Vita

Capt Derek Williamson was born 6 July 1976 in Jefferson City, MO. He graduated Jefferson City High School in 1994 and immediately began college at Lincoln University also in Jefferson City, MO. He enlisted in the Air Force December 1996 and served three years as a Chinese Mandarin Cryptologic Linguist before being selected for a Reserve Officer Training Corps program which he began at Hawaii Pacific University in Honolulu, HI, in December 1999. After commissioning in December 2001 with a BS in International Relations, he served for a year as the Assistant Regional Director of Admissions at The Ohio State University in Columbus, OH. From there he went to Whiteman AFB, MO, to begin his career as a Logistics Readiness Officer serving as the base War Reserve Material (WRM) officer, Traffic Management Flight commander and Fuels Management Flight commander in turn. In August 2006, he entered the Air Force Institute of Technology Graduate School of Engineering and Management. Upon graduation, he will be assigned to the Air Force Research Laboratory at Wright-Patterson AFB, OH.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From – To)*
27-03-2008	Master's Thesis	Oct 2006 – Mar 2008

4. TITLE AND SUBTITLE

Inland Resupply Without a Road or Runway: Airdrop Solutions Including High-Altitude Precision Systems

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Williamson, Derek L., Captain, USAF

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)

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8. PERFORMING ORGANIZATION REPORT NUMBER

AFIT/GLM/ENS/08-15

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

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10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Given the variety of airdrop options now available, it may be difficult to determine the best mix of paradrop and aircraft types to employ, how the chosen types affect delivery weight capacity and what the least cost would be for the operation while still accomplishing the mission regarding drop zone weight, altitude, offset, and accuracy requirements. This research creates a planning tool to analyze these decisions and also identify trends regarding the best aircraft and paradrop types to use considering cost and capability in a strategic rather than tactical setting. This is accomplished through the formulation of a linear program implemented as a spreadsheet model for several different scenarios. This research indicates that new high-altitude precision airdrop (HAPAD) systems will make conventional airdrop obsolete due to both cost and performance and that C-5 aircraft, if used, have the potential to dramatically increase airdrop capacity at competitive cost, particularly when using 30,000 lb HAPAD. Also, regarding cost, this research suggests airdrop system design life needs to match life expectancy and that all relevant costs must be included to make an accurate comparison with alternative resupply methods.

15. SUBJECT TERMS

High-Altitude Precision Airdrop, JPADS, Strategic Airdrop, Transportation Problem, Convoy Replacement

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**		
U	U	U	UU	172

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